

SUMMARY REPORT
OF THE
MINES BRANCH
OF THE
DEPARTMENT OF MINES
FOR THE CALENDAR YEAR ENDING DECEMBER 31
1913

PRINTED BY ORDER OF PARLIAMENT



OTTAWA
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EXCELLENT MAJESTY

1914

To His Royal Highness the Duke of Connaught and Strathearn, K.G., etc., Governor General of Canada.

MAY IT PLEASE YOUR ROYAL HIGHNESS:

The undersigned has the honour to lay before Your Royal Highness, in compliance with 6-7 Edward VII, Chapter 29, Section 18, the Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1913.

(Signed) LOUIS CODERRE,
Minister of Mines.

HON. LOUIS CODERRE,
Minister of Mines,
Ottawa.

SIR,—I have the honour to submit herewith, the Director's Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1913.

I am, Sir, your obedient servant,

(Signed) R. G. McCONNELL,
Acting Deputy Minister.

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SUMMARY REPORT
OF THE
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FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1913.

R. G. McCONNELL, Esq., B.Sc.,
Acting Deputy Minister,
Department of Mines.

SIR,—I have the honour to submit herewith, the Summary Report of the Mines Branch for the calendar year ending December 31, 1913.

CHANGES IN STAFF.

F. Ransom, B.Sc., Assistant Engineer, Ore Dressing and Metallurgical Division, resigned April 30, 1913.

H. V. Anderson, Mechanical Draughtsman, was transferred on August 9, 1913, to the Department of Marine and Fisheries.

The following additions were made to the staff of the Mines Branch during 1913:—

Mrs. O. P. R. Ogilvie, appointed June 26, 1913, as Librarian.

Frederick E. Carter, B.Sc., Dr. Ing., appointed July 1, 1913, as Assistant Engineering Chemist, Division of Fuels and Fuel Testing.

W. B. Timm, B.Sc., appointed July 21, 1913, as Assistant Engineer, Ore Dressing and Metallurgical Division.

Eugene Juneau, appointed July 28, 1913, as Draughtsman.

M. M. Farnham, B.A., appointed August 18, 1913, as Secretary, Mines Branch, Department of Mines.

Wm. Campion, appointed December 11, 1913, as Mechanical Draughtsman.

ORGANIZATION: CLASSIFIED LIST OF STAFF.

The following is a complete list of the technical officers and other employees at present on the staff of the Mines Branch:—

Administration staff:—

M. M. Farnham, B.A., secretary to the Mines Branch.

Miss J. Orme, private secretary.

W. Vincent, filing clerk.

G. Simpson, mailing and distribution clerk.

Miss I. McLeish, typewriter.
Miss W. Westman, typewriter.
Miss M. E. Young, typewriter.
A. F. Purcell, messenger.
L. J. MacMartin, messenger.
John H. Fortune, caretaker.

Division of Mineral Resources and Statistics:—

J. McLeish, B.A., chief of the division.
C. T. Cartwright, B.Sc., assistant engineer.
J. Casey, clerk.
Mrs. W. Sparks, clerk.
Miss G. C. MacGregor, B.A., clerk.
Miss B. Davidson, typewriter.

Division of Fuels and Fuel Testing:—

B. F. Haanel, B.Sc., chief of the division.
J. Blizzard, B.Sc., technical engineer.
E. Stansfield, M.Sc., engineering chemist.
F. E. Carter, B.Sc., Dr. Ing., assistant engineering chemist.
A. von Anrep, peat expert.

Division of Chemistry:—

F. G. Wait, M.A., chemist, chief of the division.
M. F. Connor, B.A. Sc., assistant chemist.
H. A. Leverin, Ch. E., assistant chemist.
N. L. Turner, M.A., assistant chemist.

Ore Dressing and Metallurgical Division:—

G. C. Mackenzie, B.Sc., chief of the division.
W. B. Timm, B.Sc., assistant engineer.

Division of Metalliferous Deposits:—

A. W. G. Wilson, M.A., Ph.D., chief of the division.
E. Lindeman, M.E., assistant engineer.
A. H. A. Robinson, B.Ap.Sc., assistant engineer.

Division of Non-metalliferous Deposits:—

H. Fréchette, M.Sc., chief of the division.
H. S. de Schmid, M.E., assistant engineer.
L. H. Cole, B.Sc., assistant engineer.
S. C. Ells, B.A., B.Sc., assistant engineer.

Division of Explosives:—

J. G. S. Hudson.

Note: This Division will be fully organized on the passage of the proposed Explosives Bill.

Draughting Division:—

H. E. Baine, chief draughtsman.
L. H. S. Pereira, assistant draughtsman.
A. Pereira, draughtsman.
E. Juneau, draughtsman.
Wm. Champion, mechanical draughtsman.

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OUTSIDE SERVICE.

Dominion of Canada Assay Office, Vancouver, B.C.:—

G. Middleton, manager.
J. B. Farquhar, chief assayer.
H. Freeman, assistant assayer.
A. Kaye, assistant assayer.
D. Robinson, chief melter.
G. N. Ford, computer and bookkeeper.
T. B. Younger, clerk.
R. Allison, assistant melter and janitor.

INTRODUCTORY.

While work along the lines of the three leading activities of the Mines Branch:

- (a) Investigation of the metallic and non-metallic deposits of Canada;
- (b) Experimental tests of ores, metals, and fuels;
- (c) Gathering and tabulating statistics of the industrial resources of the country, etc.,

has—up to the limits of staff, equipment, and opportunity—been carried on as usual during this year, several investigations of outstanding importance may be specifically mentioned: (1) examination of the Tar Sand Deposits of Alberta; (2) examination of the Petroleum and Natural Gas Resources of Canada; (3) exploration of the Deposits of Low-grade Titaniferous Iron Ores and Magnetic Iron Sands of Natashkwan, Que., and (4) an attempt to demonstrate that the large quantities of Cobalt Residues resulting from the smelting of the silver-cobalt ores of Ontario can be utilized to advantage in the arts and industries.

Preliminary reports, dealing with these special investigations, will be issued at an early date; and when complete data are available, final reports, for general distribution, will be issued.

ORE-DRESSING AND METALLURGICAL LABORATORIES.

The enlargement of the Ore-dressing and Metallurgical Laboratories has been completed. It is now proposed to install, in conjunction therewith, an experimental roasting and sintering plant—with all the necessary equipment. This complete, modern equipment will enable the Mines Branch to conduct dressing tests on various Canadian ores and minerals, on either a large or small scale.

TESTING OF COAL, LIGNITE, AND PEAT FUELS.

In order that the country may possess definite and accurate information relative to the qualities of the different coals supplied for consumption, either from domestic or foreign sources, an experimental investigation—having in view the determination of the values of these coals, for the production of power and industrial gas—was begun at the Fuel Testing Plant of the Mines Branch; and arrangements were made with a number of producers whereby several 30 ton shipments of coal and several similar shipments of lignite were received at the laboratory for experimental purposes. In addition, a number of samples of mine coal—averaging about three per month—have been received for examination.

The testing of foreign and domestic coals, analysing of samples of natural gas from the west, and investigation of several peat bogs in Ontario, have kept

the Fuel Testing Division working at high pressure, and the work of the Division has been seriously hampered by the lack of a sufficient staff to handle the work which has accumulated. When the final reports of these varied activities are published, the essentially practical character of the work will be seen.

ZINC INVESTIGATION.

In 1910, an investigation was commenced of processes for the profitable reduction of the refractory zinc ores of Canada. This investigation is still being continued by the Mines Branch, under the supervision of Mr. W. R. Ingalls of New York.

In the Annual Summary for 1912, a progress report by Mr. Ingalls showed that elaborate preliminary experiments in the electrothermic smelting of zinciferous ores were being conducted at McGill University, Montreal. After experimentation with some thirty-two modifications of the McGill electric furnace—having as the main objective the solution of the “condensation problem”—an approved form of electric furnace was at last agreed upon, as being suitable for trial on a commercial scale; and the basis of operations was transferred from Montreal, Que., to Nelson, B.C., where facilities for conducting trials on a commercial scale were available. A necessarily brief statement, by Mr. Ingalls, of the results of the trials at Nelson in 1913, will be found in a subsequent chapter of this report.

ELECTROTHERMIC PRODUCTION OF IRON AND STEEL.

With a view to preserving Canada's historic continuity in the development of the electrothermic process for the reduction of refractory iron ores—which began, practically, with the experiments at Sault Ste. Marie, Ont., in 1907—Dr. Kalmus of Queens University, carried on, during 1913, further investigations and researches into the electrothermic production of iron and steel. Data gathered from all parts of the world, and the results of experiments, made in the Research and Metallurgical laboratories of the School of Mining, Kingston, Ont., are given in outline on pages 18-20; and this preliminary statement is to be followed, later on, by a comprehensive, detailed report.

SPECIAL METALLURGICAL INVESTIGATIONS: COBALT.

Early in 1914, was published Part I of the special series of studies conducted for the Mines Branch, at the Research and Metallurgical laboratories of the School of Mining, Kingston, Ont., under the supervision of Dr. H. T. Kalmus: namely, “Preparation of Metallic Cobalt by the Reduction of the Oxide”. It is expected that Part II, on “The Physical Properties of the Metal Cobalt”, will be published during the succeeding summer.

These technical papers give, in detail, the results of original research work, and of the application of new methods of metallurgically treating one of Canada's chief industrial assets—the silver-cobalt ores of Ontario. Hitherto the operators of smelters have paid for the silver content of the ores only, hence the miner has received nothing for the valuable cobalt constituent. The metal cobalt has, however, long been suspected of possessing—like nickel—physical properties that render it of considerable economic value when alloyed with certain other metals. The objective, therefore, of the research work being conducted at Queen's University is, to determine, scientifically, the properties of cobalt; to test, experimentally, its adaptability for alloying economically with other metals; and to discover new commercial uses for the product, in the interests of the mining industry of Canada.

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The following is a list of the series of papers to be published:—

- I The preparation of metallic cobalt by reduction of the oxide. (Printed).
- II A study of the physical properties of the metal cobalt. (In the press).
- III Electro-plating with cobalt and its alloys.
- IV Cobalt alloys of extreme hardness.
- V Cobalt alloys of non-corrosive properties.
- VI Cobalt steels.

On page 99 is a short outline report, by Dr. Kalmus, of the progress of the investigations made during the season 1913.

NATIONAL PROTECTION AGAINST THE UNSKILFUL USE AND HANDLING OF
DANGEROUS EXPLOSIVES.

During 1913, many accidents—attributed to unskilful use, or careless handling of high explosives—occurred in Canada. The evidence gathered by the Explosives Division of the Mines Branch, clearly shows that a large number of these accidents would not have taken place had there been in existence a proper code of laws regulating the manufacture, importation, and testing of explosives in the Dominion.

It was expected that the Explosives Bill originally prepared in 1910, by the Mines Branch—in conjunction with the Department of Justice—would be passed by Parliament in 1913; but its enactment was delayed until 1914, in order that every precaution could be taken to see that the principles of the Bill did not conflict with Provincial rights and laws; and that its provisions were equitably formulated to meet the conditions of manufacture and use.

Immediately the Explosives Bill receives the sanction of Parliament, and as soon thereafter as Parliament provides the necessary funds, the suitable buildings already planned will be erected, the necessary appliances and machinery will be installed, and an efficient staff will be duly appointed and organized.

When the Explosives Division, with its staff of chemists and inspectors, is thoroughly organized, and the testing plant completed and in operation, the laws regulating the manufacture, importation, and testing of explosives can be put into force. Then, it is confidently hoped that the deplorable accidents so often occurring in all parts of the Dominion, will be reduced to a minimum.

CHEMICAL LABORATORIES: ENLARGED SCOPE OF WORK.

The chemical analysis of metalliferous ores, and of non-metallic minerals, together with the physical examination of mineral specimens, has always been an important part of the work of the Mines Branch; but, hitherto, there have been no modern facilities for carrying out another important phase of work, namely, analysis of spring and mineral waters. Steps are being taken, however, to provide complete apparatus and appliances for water analysis in connexion with the headquarters chemical laboratories at Ottawa.

The illustrations, pages 180, 182, show, in detail, our recently established general chemical laboratories on the third floor of the Mines Branch Building, Sussex St., Ottawa. This laboratory is equipped with the latest appliances, and apparatus; but it is overcrowded with work, and is quite unable to meet the increasing demands of the country, owing to the lack of an adequate staff of assistant chemists.

DOMINION ASSAY OFFICE, VANCOUVER, B.C.

In the Summary Reports for 1911 and 1912, attention was drawn to the fact that the usefulness of the Assay Office was very much impaired yearly, owing to the imposition of a charge of one-eighth of one per cent, plus royalty or export tax, on the gross value of the Yukon gold bullion deposited, thus causing the diversion of gold bullion from Vancouver to Seattle or San Francisco, with consequent loss of much local business and trade.

On January 16, 1913, this much needed reform was made by Order in Council and the remarkable increase of business detailed in the general report of the Assay Office (p. 145) shows that this radical change was well-advised.

During the year, 783 deposits of gold were made, requiring 926 melts, and 926 assays, including the assembling and remelting of the individual deposits after purchase into bars weighing 1,000 troy ounces each, and assaying of same. The net value of the gold and silver contained in the deposits was \$1,448,625.37.

GENERAL CONSIDERATIONS AND ACKNOWLEDGMENTS.

The programme of field work carried out by the Mines Branch during the year 1913 has been largely a continuation of work commenced in previous years. This continuation work is chiefly due to the wide extent of the fields needing investigation.

It is impossible to make a systematic study of many mining industries and the natural deposits upon which they are dependent, without an extensive examination of fields embracing large areas: all of which requires much time; in some instances, many years of patient labour. But when the series of reports on the iron ores, copper ores, building stones, and fuel resources, etc., of Canada, now in course of preparation, are published, the country will possess a basic body of technical literature which should prove of inestimable value in the development of much needed industries.

The many letters received from mining men, manufacturers, and prospectors during 1913, expressing approval of investigation work done along certain lines, and expressing appreciation for technical advice freely given, are evidence that the essentially practical work outlined in this Annual Summary Report is meeting a pressing public want. It cannot be too widely known that the services of the various divisions of the Mines Branch are always available for aiding any legitimate enterprise which has for its aim the development of some phase of the mining and metallurgical industries of Canada.

FIELD WORK.

COPPER, PYRITES, PLATINUM.

Dr. Alfred W. G. Wilson spent about eight and a half months of the year at Ottawa engaged in office duties. During this period his report on the Copper Smelting Industries of Canada was completed and handed to the editor, and some progress was made on the companion volume dealing with the Copper Mining Industries of Canada. During this season only three and one half months were spent in field work. From July 26 to September 22, except for one week's interval in August, Dr. Wilson was attendant on the International Geological Congress and its excursions; having been appointed one of the official delegates to the Congress from the Mines Branch of the Department of Mines.

The interval from September 22 until November 4, was spent on field work in British Columbia on several problems requiring attention. During this period Dr. Wilson obtained some additional information for the report on Copper Mining.

On October 4, I telegraphed instructions to Dr. A. W. G. Wilson to visit the localities near Nelson at which it was alleged that platinum had been discovered, and to obtain samples for assay.

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On the receipt of my instructions, Dr. Wilson put himself in communication with the interested parties, and obtained, in all, 18 samples from the exact localities pointed out by these parties as the places from which they had previously obtained platinum assays. Eleven of these samples were assayed in the Mines Branch laboratory, and proved to be devoid of either platinum or metals of the platinum group. Dr. Wilson concludes his report, pp. 26-27, with the statement that he can see no reason for believing that metals of the platinum group occur in the localities selected by the most interested parties as representative, and also that he has not seen any evidence to show that platinum occurs commercially in the Nelson district.

In December, 1912, a number of samples were obtained from this district by Mr. Wm. Fleet Robertson, Provincial Mineralogist of British Columbia.¹ One set of these samples was submitted to our office for assay, and no platinum was found in any of them. Similar sets of samples were sent to a number of the best recognized experts in this line of work in the world.

Assays were made by the following:—

Johnson, Matthey & Co., London, England, Assayers to the Royal Mint.

Dr. Frederick P. Dewey, Washington, D.C., Chief Assayer to the United States Mint.

Ledoux and Company, New York.

Consolidated Mining and Smelting Company, Trail, B.C.

British Columbia Government Laboratory.

The S. S. White Dental Manufacturing Company.

With the single exception of the S. S. White Dental Manufacturing Company, these assayers all report that they could not find any platinum in the samples sent.

In the face of this testimony, it is clear that platinum, in commercial quantities, cannot occur in these localities, in the places where certain interested parties claim that it has been found.

None of the interested parties who have been claiming that platinum occurs in this district have, so far as I am aware, ever submitted to this office any samples containing platinum. No one has ever shown a qualified expert any platinum alleged to have been obtained from the district.

With reference to the list of assays sent to this office, by interested parties, no assay certificates or certified copies of certificates of assay are submitted, and no connexion between these alleged assays and the Nelson localities is established. Among the assays, eleven on one sheet, and six on another, are credited to Mr. W. E. Newton, Assayer of the Van Roi Mine, Silverton, B.C. In each of these platinum is stated to occur, the amounts varying from 0.15 ounces per ton to 21.52 ounces. In a personal letter to Dr. Wilson of my staff, under date of December 5, 1913, Mr. Newton writes as follows:—

“As there have been so many false and misleading statements made with regard to my connexion with this matter, I wish in justice to myself, to explain the facts in regard to it.

“Soon after A. G. French claimed to have discovered platinum in the dikes in question, I was asked by several interested parties to make assays for them. I informed them that I had no experience with platinum and that I had neither the time nor the means at my disposal to determine the amounts of platinum metals in these rocks. I agreed to make some fire assays and see if I could get any metal from the samples by fire assay. Further than this I was not prepared to go. They consented to this and I made a considerable number of fire assays, getting beads in a great many cases, and I thereupon informed the owners that

¹ Annual Report, Minister of Mines, British Columbia, 1912, pp. 116-160.

I had obtained some metal by fire assay, but that I did not know what it was. Some of these beads I subsequently tested for gold and silver with negative results. I have never given a certificate to anyone showing platinum or platinum metals. In some cases I have given certificates showing 'Total precious metals', and in such cases I informed the owners that the assay included all gold and silver, and the platinum, if such were present.

"After I had been doing this work for some time, Dr. W. H. Willson, of Nelson, gave me some material which he stated was the slag obtained from retorting the amalgam from the mill run made at the Granite-Poorman. He asked me to see if there was any metal in it, and if so, to try and determine the quantities of each metal. For a long time I declined to test it but finally consented to do the best I could with it. I made him thoroughly understand that I did not consider myself capable of doing such expert work and that I would under no circumstances guarantee the results. I only consented to try the material at all, after he agreed to treat the matter as strictly confidential, and not to be made public. This he promised to do, so I parted some of the metal obtained and determined the gold and silver. From my nitric acid solutions I obtained a black precipitate on boiling with formic acid and I informed Dr. Willson that this possibly was platinum or palladium. On trying to test this material chemically, I was unable to make it answer such tests as I was able to apply, so I told Willson that this made me think that the metal was not platinum at all. In the course of such further work as I had time for before leaving the Van Roi mine I did not succeed in finding out what the metal was, and since then I have been unable to touch the matter at all.

"Since then I understand that you have been furnished with the results of a lot of these tests, so I wish you to understand thoroughly my position in the matter.

"My own experience makes me feel sure that precious metal of some kind exists in some of the rocks in question, but I do not claim and never have claimed that it is platinum."

It will be noted that no direct connexion is established between the original localities and Mr. Newton, who made these assays—the material having been given to him by interested parties, including Dr. Wm. H. Willson of Nelson. You will also note that Mr. Newton specifically states: "I do not claim and never have claimed that it is platinum." It is hardly necessary to add that the alleged assay returns credited to Mr. Newton are valueless. The effect of this is also to discredit completely all the assays submitted.

With regard to a copy of a report on the Rover Creek locality, submitted to this office, and addressed to Messrs. McQuarrie and Robertson, and signed by R. J. Elliot, numerous statements in the report are sufficient to discredit it. In a section headed "Geology" several well known scientific terms are incorrectly used. In a paragraph headed "*Permanency*" the statement is made that "There is simply millions of tons of ore in sight and carrying good values (in platinum and associated minerals)," a statement that does not agree with the opinion of competent engineers and geologists of our own staff, nor with the opinions of several independent engineers who have visited the locality. If this ore were known to exist, the interested parties would have no difficulty in realizing on it.

With reference to a further examination of the locality, there does not appear to be anything to examine. The exact localities where the alleged discoveries were made have been sampled by the most competent men available, and no platinum has been found. The engineers of several private corporations interested in mining have examined the localities, and found nothing. The entire district was explored in detail by a party from the Geological Survey Branch of the Department of Mines (Mr. O. E. LeRoy and party), and I presume his

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report is now in the press. His summary report was published in 1911. Mr. LeRoy has also made a special examination of the Granite-Poorman mine since the alleged discoveries of platinum. I have no information as to the report which he made. A further examination would be only to duplicate the work of Mr. LeRoy, and would serve no useful purpose.

IRON ORES.

Mr. E. Lindeman spent the field season in Cape Breton, gathering data necessary for completing his report on the Iron Ore Resources of the Maritime Provinces.

Occurrences of iron ore have now and then been reported in various localities of Cape Breton. The most common type is hematite, which is generally found associated with the Lower Carboniferous series, occupying irregular fissures and cavities in these rocks. It is also found in the Pre-Cambrian series, near its contact with the Lower Carboniferous formation. The deposits are, however, of little economic importance, owing to the irregular and pockety character of the hematite.

In Cape Breton occurrences of magnetite are not common, and, where found, the extent of the ore bodies is very limited.

Last year a discovery of magnetite at Upper Glencoe, Inverness county, attracted considerable attention, and large land areas were taken up in search for iron ore. The heavy drift covering of these areas renders prospecting difficult, and, so far, no discovery has been made but that on the farms of Hugh and John McEachern, where magnetite occurs in several lenses along the contact of Pre-Cambrian limestone and granite. Judging from the magnetometric survey made by Mr. Lindeman, these ore deposits are, however, of very small extent, and are not likely to be of economic importance.

In the latter part of July, Mr. Lindeman took part in excursions A 1 and A 3 of the International Geological Congress, acting as guide at Bathurst, N.B., and at Moose Mountain, Ont.

INVESTIGATION AND EXAMINATION OF MAGNETIC IRON SANDS AT
NATASHKWAN, QUE.

During the field season, the examination and exploration of the magnetic iron sands near the mouth of the Natashkwan river, on the lower St. Lawrence, were continued.

In previous summers, the ground lying between the river and the gulf was examined for $3\frac{1}{2}$ miles below the mouth of the river. Further investigation showed that the iron bearing sand continued for 2 miles farther down the gulf. By the use of a 4" Empire Drill and equipment, this ground, representing an area of 340 acres, was examined during the summer.

The work consisted of laying off the ground into squares, 500 feet to the side; a drill hole being put down on each of the four corners and one in the centre of the square. In this manner the area was systematically sampled. The sand from the bore holes was bagged, numbered, and shipped to the Testing Laboratory of the Mines Branch for analysis and concentration. Levels were run to ascertain the topography of the ground for plotting, and to determine the tonnage of magnetic sand.

The party consisted of 15 men, under the charge of Mr. C. S. Parsons and two assistants. The supervision of the work was under Mr. George C. MacKenzie, chief of the Division of Ore Dressing and Metallurgy.

LODE MINING IN THE YUKON.

During the field season of 1913, Mr. T. A. MacLean was retained by the Mines Branch to continue the investigation of lode deposits in the Yukon, begun by him in the year 1912.

The previous examinations verified the fact that throughout the whole district traversed, quartz was abundantly found. Certain preliminary values were established in connexion with all the known deposits of Dawson and Duncan Creek mining districts, and also in connexion with a few deposits in southern Yukon. Some of the prospects proved sufficiently good to suggest that a more detailed sampling, following further development, might demonstrate that there was reasonable hope of these prospects becoming mines. A report to this effect would, it was thought, be of considerable assistance to prospectors in enabling them to interest, in legitimate mining prospects, individuals or corporations with money to invest.

Many of the prospectors had reached a point beyond which, through lack of funds, they could not proceed with development work, hence in the interests of these prospectors and of the district as a whole, the work was undertaken. A summary of Mr. MacLean's work appears on page 37 of this report.

In addition to this, Mr. MacLean's report will be found to embrace a number of prospects not previously examined by him, with special reference to certain areas in the White River district, where it was supposed extensive copper deposits existed.

NON-METALLIC MINERALS USED IN CANADIAN INDUSTRIES.

During the year Mr. Fr  chette completed the collection of data for his report on the uses of the non-metallic minerals in the Canadian manufacturing industries. Much of his time has been devoted to the compilation, in the form of tables, of the data gathered during the past three years, and to the preparation of his report. This will be published early in 1914.

Mr. Fr  chette attended the Toronto meetings of the International Geological Congress and accompanied four of the excursions of the Congress to the mining districts; namely, A 2, to the marble, sodalite, and corundum deposits of central Ontario; A 5, to the asbestos and chromite deposits of Quebec; B 10, to the talc and pyrite deposits of Hastings county; and C 2, to the mining districts of British Columbia, Cobalt and Porcupine, on the second and fourth of which he acted as secretary, and assistant secretary, respectively.

PHOSPHATE AND FELDSPAR.

Mr. Hugh S. de Schmid continued his work upon phosphate and feldspar, during the early part of the summer, and is preparing reports upon both these subjects which will be issued during the current year. During August, and part of September, he took part in certain excursions organized in connexion with the 12th Session of the International Geological Congress, accompanying excursion A 8 as guide, and transcontinental excursion C 1, in the capacity of assistant secretary. In addition, he attended the session in Toronto, of the above Congress, as a delegate of the Mines Branch.

Subsequently, Mr. de Schmid proceeded to the Yellowhead Pass district, British Columbia, in order to examine and report on the white mica deposits of that area. A description of the occurrences will be found on page 42 of this report.

Mr. de Schmid's conclusions are, that while mica of high quality exists in the Yellowhead and Big Bend districts of British Columbia, the occurrences are too remote, in the majority of cases, to allow of profitable mining at the present time, and for some years to come.

GYPSUM AND SALT.

Mr. L. Heber Cole was, during the first six months of the year, engaged in completing a revised edition of the Mines Branch monograph on gypsum. During the months of July and August, he attended the meetings of the International Geological Congress in Toronto, and accompanied the following ex-

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cursions: A 1, the Maritime Province excursion, visiting the gypsum deposits of Nova Scotia and New Brunswick; A 10, an excursion to the south of Montreal, covering the Pleistocene geology of that district—on which excursion he acted as secretary; and C 1, one of the western transcontinental excursions after the meetings.

The month of September was spent examining the salt springs in Manitoba, obtaining necessary data for completing a bulletin on salt, to be issued early in 1914.

INVESTIGATIONS OF BITUMINOUS SANDS OF NORTHERN ALBERTA.

Mr. S. C. Ells spent a part of the field season of 1913 in making a preliminary examination of the bituminous sands of northern Alberta. The existence of these deposits has long been recognized, yet, up to the present time, our knowledge of their actual extent and real economic value has been largely speculative. In the past, absence of transportation facilities has effectually prohibited any serious attempt to prospect, or to develop these deposits. It is anticipated, however, that with the completion of the Alberta and Great Waterways railway, in the near future, the present handicap will be removed.

During the past season, upwards of 250 outcrops of bituminous sand were noted, and many samples collected. Results of physical and chemical determinations of these samples will be available early in 1914. Meanwhile, no definite expression of opinion regarding the quality of the material can be made. It is, however, apparent that, owing to thickness of overburden, variation in quality of material, and considerations affecting transportation, a majority of the exposures in the McMurray district may, at the present time, be eliminated from further consideration.

During the past twenty years numerous attempts have been made in the United States to extract the bitumen from bituminous sands and sandstones. Up to the present time, these attempts have not met with commercial success. But bituminous sands have been utilized to a considerable extent in the construction of various classes of roads and pavements. Certain of these pavements, subjected to varying traffic conditions, have proved decidedly successful. On the other hand, many of the earlier pavements laid with bituminous sand have proved unsatisfactory.

From a careful consideration of available data, it appears that lack of appreciation of the true nature of the material used, together with absence of proper manipulation, have been responsible for many of these failures. It is evident, therefore, that the most careful study should be given to the chemical, and more especially to the physical, character of our Alberta bituminous sands, as a preliminary step to actual attempts at paving with this material. Failure to properly appreciate the importance of these features can only end in unsatisfactory results, and in financial loss.

BUILDING AND ORNAMENTAL STONES OF CANADA.

The examination of the building and ornamental stones of Canada has been continued by Professor W. A. Parks of Toronto University.

The field work for 1913 was confined to the Province of Quebec, and consisted in the continuance of investigations begun the previous season.

The results of these two seasons' work, when issued, will afford information not only regarding the various localities in which the different varieties of stones may be obtained, but will also contain references to the transportation facilities and other conditions that affect production. There are, in the Province of Quebec, a considerable number of quarries which were at one time large producers, but owing to various causes, are at present lying idle. Professor Parks has, conse-

quently, given special attention to the study of the circumstances that have adversely affected the stone-working industry.

After completing the work in the Province of Quebec Dr. Parks spent some time visiting certain quarry lands in the township of Nepean, county of Carleton, Ontario, and also a belt of sandstone deposit along the eastern shore of Lake Timiskaming.

Up to the present time these investigations have been confined to the Province of Ontario, the Maritime Provinces, and the Province of Quebec, but it is the intention of the Department to further continue the investigations, so as to include all the Provinces of the Dominion, the data thus collected to constitute a monograph on the Building and Ornamental Stones of Canada.

It is, moreover, anticipated that the work will prove of special value to builders, contractors, and others, by indicating the localities in which each particular variety of stone may be most readily obtained.

Two volumes of this report have already been issued. Volume I, consisting of parts 1 and 2, contains a systematic investigation of the building and ornamental stones of Ontario, and Volume II covers a discussion of the building and ornamental stones of the Maritime Provinces. Volume III, describing the building and ornamental stones of Quebec, is at present in the press. Copies of this volume should be ready for public distribution not later than November, 1914.

PETROLEUM AND NATURAL GAS RESOURCES OF CANADA.

Mr. F. G. Clapp and his assistant, Mr. L. G. Huntley, continued their field and office work on the monograph dealing with the petroleum and natural gas resources of Canada. The completed report was received in December, 1913, and has been sent to press.

This report will outline the history of developments, status of production, stratigraphy, drilling methods, markets, methods of transportation, quality, utilization, and such other technical details as are necessary in exploiting these resources to the best advantage. Such a report is necessary for an operator in one field, who may wish to be informed regarding conditions or methods existing in some other field; and will be valuable to the layman who may intend entering the petroleum or natural gas business, or associated enterprises.

SURVEYS OF PEAT BOGS.

During the field season, Mr. A. Anrep, peat expert of the Mines Branch, examined a number of bog areas in different sections of the Province of Ontario, and made detailed surveys of several. Some small bogs in Prince Edward Island were also examined and surveyed.

OFFICE WORK OF CERTAIN DIVISIONS.

DIVISION OF CHEMISTRY.

The Division of Chemistry is now located in the new laboratories, which occupy about one-half of the floor space on the third floor of the Mines Branch building. These laboratories have been equipped with the latest appliances and are able to undertake almost any type of investigation in inorganic chemistry. The chief chemist and his assistants have been fully occupied throughout the year. A description of these laboratories is given in a later chapter in this report.

DIVISION OF FUELS AND FUEL TESTING.

The work of this Division, during the fiscal year, consisted in the preparation of the monograph entitled "Peat, Lignite, and Coal; their value as fuels for utilization in the By-Product Recovery Producer"; the testing of commercial samples of lignite from five representative mines in the Province of Alberta

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for the purpose of determining their value as steam coals, and for the production of a power or industrial gas when burned in the gas producer; and in the preparation of the final bulletin setting forth the results of these tests.

In addition to the above work, complete analysis of many mine and other samples of coal, natural gas, and petroleum, have been made in the chemical laboratory of the Fuel Testing Station.

The completion of the alterations to, and enlargement of, the Fuel Testing Station and its laboratory, begun in 1911, enables this Division to carry out complete tests and investigation of the various fuels met with in Canada.

The work of investigating and surveying the peat bogs of Canada was continued during the past season, some of the more important bogs of Quebec and Ontario being carefully examined and mapped.

ORE DRESSING AND METALLURGICAL DIVISION.

The new ore dressing laboratories for the testing of commercial samples of Canadian ores were almost completed during the present (1913-14) fiscal year.

The installation of machinery in the new testing laboratory has been practically completed. To the present equipment will be added a Flotation Process. The laboratory will then be equipped with the necessary apparatus and machinery for experimental ore dressing and concentration of ores, either on a large or small scale. A bulletin is being prepared, to be placed before the public, which will give a detailed description of the plant and the work to be carried on by this Division. Information regarding the testing of ores can be obtained on application to the Director of the Mines Branch.

During the first part of the year, the attention of the Chief of the Division and his assistant was devoted almost entirely to preparing plans and supervising the installation of machinery. The testing of ores was discontinued, pending the completion of this work, but, on various applications being made to the department for ores to be tested, it was found necessary to commence experimental work on such portions of the plant as were completed, and continue with the equipment at the same time.

During the latter part of the year, laboratory tests were made on molybdenum ores from Renfrew county, Ontario; a copper ore from the Madoc Mining Company, Goudreau, Ontario; a magnetic iron ore from Lavant township, near Flower station, on the Kingston and Pembroke railway, and a zinc ore from the Hudson Bay mine, Salmo, B.C. A large scale test is at present being conducted on a banded magnetite and hematite ore from Groundhog, Ontario.

Mr. George C. Mackenzie, Chief of the Division, devoted a part of the field season to the investigation being carried on by this Division of the deposits of magnetic iron sands, near the mouth of the Natashkwan river, on the lower St. Lawrence. On the first of October, he was sent by the Department to Nelson, B.C., to superintend the construction and equipment of an experimental testing plant for the reduction of refractory zinc ores of British Columbia. During his absence, Mr. W. B. Timm, Assistant Engineer, had charge of the Ore Testing and Concentration Laboratories.

The equipment of the new Testing Laboratory with the latest improved ore dressing and concentrating machinery and apparatus, has met with the approval of the mining public to such an extent, and the work of this Division has increased so rapidly, that it has become necessary to ask for an immediate increase to the present staff, by the appointment of an assayer and chemist, two more technical assistants, and a mill man.

In connexion with the Ore Dressing and Concentrating Laboratory, the installation of an experimental roasting and sintering plant will be undertaken some time during the coming year. When completed, this Laboratory will probably be the finest equipped testing laboratory of its kind on the continent. The reasons for its establishment were set forth in a memorandum to the then Minister of Mines, written in July, 1912. The following is an excerpt from this memorandum:—

“During the summer and fall of 1910, the Mines Branch of the Department of Mines installed a testing plant for the concentration of low grade magnetic iron ores. This installation consists of a Gröndal concentrating unit, comprising an ore crusher, a ball mill and two Gröndal separators. The machines are of standard commercial size, the capacity of the unit being anywhere from 50 to 100 tons of crude ore per 24 hours. The installation of this machinery was made with the view of proving the amenability of Canadian low grade magnetic iron ores to methods of concentration carried out successfully in the United States, England, Sweden and Norway. The process is both simple and effective, having for its purpose the concentration or enrichment of the iron values, together with the elimination of various obnoxious minerals usually associated with these low grade ores.

The process of magnetic concentration as applied to a certain inferior class of iron ores has to-day a firmly established and well recognized value in the above mentioned countries. The product is not only high grade, being eminently suitable for the production of the finer grades of iron and steel, but constitutes also a valuable auxiliary to the main supply of natural ores.

The United States leads all other countries in its resources of high grade natural iron ores, but, notwithstanding this fact, several of the larger iron corporations in that country have found it exceedingly profitable to employ this method of concentration in the utilization of low grade ores. This is the more worthy of note when it is considered that iron and steel manufactured from those concentrated ores are competing successfully with iron and steel made from the natural and apparently cheaper ores.

About 17 per cent of the iron ores smelted in Canadian furnaces during 1909 was of domestic origin. This small proportion is due to the fact that we have not as yet discovered merchantable deposits of sufficient magnitude to meet requirements. The iron and steel companies of the Maritime Provinces, it is true, secure the major portion of their ore supply from Newfoundland; but the Ontario furnace man is almost entirely dependent for his ores upon the American ranges of Minnesota and Michigan, and in 1909 he found it necessary to import from the United States over 71 per cent of the amount required.

While our supply of merchantable ore in Canada is limited, we possess large quantities of low grade material, not so regarded, which have been, so to speak, in reserve and which have hardly been touched.

To render these impure ores in fit condition for the manufacture of iron and steel necessitates the application of a concentration process, and the fact that the vast majority of our low grade iron ores are of the magnetic variety suggests the adoption of magnetic concentration as the means whereby these ores may be utilized with profit.

As an indication of the extent to which this process would apply to Canadian ores, it will be illustrative to mention a few of the localities in which they are found. The sulphurous magnetites occurring on the coast of British Columbia have hitherto been regarded as a doubtful asset on account of their impurity. Many of these British Columbia magnetites contain copper in appreciable amounts, which might constitute a valuable by-product. The siliceous jaspilite ores of northern Ontario, and the more crystalline and sulphurous ores of the western and mid-eastern portions of the province present concentrating problems of the utmost importance. The high sulphur ores of Quebec occurring along the Ottawa and Gatineau rivers, and the large titaniferous deposits found on both sides of the St. Lawrence river are worthy of exploitation as regards their profitable use in iron manufacturing. The magnetic iron sands of the lower St. Lawrence river require more accurate investigation as regards their extent and amenability to concentration. The recent discoveries of large bodies of intermixed siliceous magnetite and hematite in New Brunswick offer additional problems, as also the semi-magnetites of the Nictaux range in Nova Scotia.

After the completion of the testing plant the Department issued a circular letter calling attention to the installation, describing its purpose, and inviting those interested to send in large samples for testing purposes. The replies to this circular letter received up to date have been most gratifying and the Department has made arrangements for the testing of some 80 tons of ores, coming in five and ten ton lots, from different localities.

That the installation of this plant has met with the warm approval of practical men engaged in the iron industry, and the Department congratulated on its effort to demonstrate the practicability of utilizing our low grade ores, is evidenced by the many appreciative letters received from representative iron operators, and others.

The Mines Branch is constantly receiving samples of ore with requests for advice as regards methods of treatment or concentration. Many of these samples are representative of the problems

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confronting the miner when he attempts to place his ore on the market, and under existing circumstances the officials of the Mines Branch can offer but meagre advice upon these diverse and very often complex problems in ore dressing.

The present installation will treat only a certain class of iron ores and by one method only. Additional machinery is required, if we are to undertake the testing of iron and other ores on a broad scale.

There is no testing laboratory in Canada sufficiently equipped to carry on experimental work of this character, and investigators are forced to go to the United States or elsewhere if they wish to make experiments of a practical nature. When the Zinc Commission was investigating methods of metallurgical treatment for the lead-zinc ores of British Columbia, they were obliged to carry on their experiments at Denver, Colorado, because there was no Canadian laboratory available. Our Universities, it is true, possess well equipped and experimental laboratories, but they are used solely for educational purposes, and the experts or professors in charge have not the time, nor do they advertise their willingness to undertake work of public nature.

It is apparent that if we are to enlarge the present installation in the direction of a National Testing Laboratory more room is required. This may be secured in a comparatively inexpensive manner by building an addition to the Fuel Testing Station, so that it forms a continuation, one story high, at the back of the present structure."

DIVISION OF MINERAL RESOURCES AND STATISTICS.

This Division is charged with the collection and compilation of statistics of the mining and metallurgical production in Canada, and the gathering and recording of information regarding the country's mineral resources.

The annual statistical reports published, include a Preliminary Report (statistics subject to revision) usually completed and issued during the first week in March, and a final and complete report, the issue of which has for several years been preceded by the separate publication of portions—five parts in 1913—as advance chapters. Thus, seven statistical reports were published during the past year.

In addition to the statistical reports, a short but comprehensive report on the Economic Minerals and Mining Industries of Canada was, with the co-operation of other members of the Mines Branch staff, prepared and published. This was given special distribution at the Canadian section of the International Exhibition at Ghent, Belgium, and at the International Geological Congress meeting in Toronto.

Mr. J. McLeish, the Chief of this Division, attended the International Geological Congress, as one of the delegates of the Mines Branch, and had charge, at the headquarters of the Congress, of a Bureau for the furnishing of information, departmental reports and maps, etc.—on the mineral resources of the country, and on geological investigations and studies. Mr. McLeish subsequently accompanied Excursion C 1 of the Congress in the capacity of Secretary.

Mr. Cosmo T. Cartwright also attended the Geological Congress, assisting in the conduct of the above mentioned Bureau, and afterwards spent two months in British Columbia, visiting various mining camps and districts on behalf of the Division.

The Report of the Chief of the Division includes a Preliminary Report on the Mineral Production of Canada during 1913, which shows the total value of the mineral production during the past year to have been (subject to final revision), \$144,031,047, which, compared with the previous year's production, shows an increase of \$8,982,751, or over 6 per cent.

DIVISION OF EXPLOSIVES.

On the fifteenth day of January, 1913, there occurred a most disastrous explosion on board the steamship "Oscar", in Nanaimo harbour, B.C. This ship was loaded with 1910 cases of dynamite and 50 kegs of black powder, and the damage to property due to the explosion was estimated at \$100,000. For-

tunately there was no loss of life reported, although a number of persons were seriously injured. As the circumstances of this explosion were related to the general question of the regulation and transportation of explosives by water in Canada, it was deemed advisable for the Department to obtain a direct report on the matter through one of its own officials, hence Mr. Joseph G. S. Hudson was despatched to Nanaimo to report on the circumstances of the accident. His report is to be published as a separate bulletin.

During the summer, Mr. Hudson was sent to the western provinces to interview the Chief Inspectors of Mines, and the Attorney-Generals, to obtain their views on the various clauses of the proposed Bill to regulate the manufacture, storage, transportation and uses of explosives in Canada. The information and critiques thus obtained, have been of great assistance in preparing the Explosives Bill for presentation to Parliament.

DOMINION OF CANADA ASSAY OFFICE VANCOUVER, B.C.

It was stated in the Summary Report of the Mines Branch for 1912, that certain conditions affected adversely the amount of bullion forwarded to the Dominion of Canada Assay Office at Vancouver, and that suggested changes were being considered by this Department.

In view of these considerations, an Order-in-Council dated January 16, 1913, authorized the abolition of the assaying and stamping charge of one-eighth of one per cent on the gross value of the gold and silver contained in deposits; the result being a considerable increase of business, 111,479.95 troy ounces of gold having been deposited with the Assay Office during the year just closed, as compared with 59,068.83 troy ounces during the calendar year 1912—an increase of 52,411.12 troy ounces.

Owing to the increase of business at the Assay Office during the year, necessitating additions being made to the membership of the staff, the following appointments were made:—

H. Freeman, appointed Assayer, March 1, 1913.

T. B. Younger, appointed Clerk, July 3, 1913.

During the year 1913, 783 deposits of gold were made, requiring 926 melts and 926 assays, including the assembling and remelting of the individual deposits, after purchase, into bars weighing about 1000 troy ounces each, and the assaying of the same. The net value of the gold and silver contained in deposits was \$1,448,625.37.

The above deposits received came from the following sources:—

Source.	No. of Deposits.	Weight.		Net value.
		Before melting.	After melting	
		ozs.	ozs.	
British Columbia.....	655	95,871.51	94,411.08	\$1,196,775.34
Yukon Territory.....	117	15,324.65	15,236.50	247,188.95
Alaska.....	11	283.79	272.91	4,661.08
	783	111,479.95	109,920.49	\$1,448,625.37

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Weight before melting.....	111,479.95	troy ounces.
Weight after melting.....	109,920.49	“ “
Loss by melting.....	1,559.46	“ “
Loss percentage by melting.....	1.3989%	

MISCELLANEOUS MATTERS.

ELECTRIC IRON ORE SMELTING IN SWEDEN.¹

The electric iron ore smelting furnaces in operation in Sweden, 1913, were:—

- 1 furnace, 3,000 H.P., Stromsna's Co., Trollhättan.
- 3 furnaces, 3,000 H.P., Uddeholm Co., Hagfors.
- 1 furnace, 12,000 H.P., Kopparberg Co., Domnarfvet.
- 1 furnace, 4, 000 H. P., Kopparberg Co., Domnarfvet.

Under construction are:—

- 2 furnaces, 3,000 H.P., Uddeholm Co., Hagfors.
- 1 furnace, 3,000 H.P., Stromsna's Co., Trollhättan.

Due to litigation between the Government and the owners of water power, the development of water power has suffered a severe setback, and thus little power has been available for new electric projects, but as the majority of these cases have been disposed of, it is expected that the construction of the projected plants will soon be resumed.

The Kopparberg Company are developing their waterfalls at Bullerforsen and Forschufvud for electric smelting. The plant, when completed, will be over 40,000 H.P. They intend to install the Helfenstein furnace, which has proved very satisfactory.

Professor Mittag-Leffler is the head of a Swedish-French company, with a capital of 30,000,000 kronor (\$8,000,000), which has been formed with the object of constructing a large water power plant, and an electric pig iron works at Sundsvall.

Mr. A. Grönwall has filed application for power and concessions from the Government for erecting two electric furnaces, 3,000 H.P. each, at Kiruna, near the Government power station at Poryus, in the extreme north.

The power plant for the two Hagfors furnaces, now under construction, is completed (6,000 H.P.), and the furnaces may be in operation this year. A 4,500 H.P. power plant for electric smelting furnaces is being built by the same company at Malta.

COPPER NICKEL STEEL.

The success attending the experiments in electrical smelting, under the direction of the Mines Branch at Sault Ste. Marie in 1906, suggested to me the probability that although the pig iron contained some percentage of copper in addition to nickel, it could be refined in an open hearth furnace, or in an electrical steel furnace to produce a first class steel.

Since then several tons of the nickeliferous pig iron made while conducting the above experiments, have been shipped to Syracuse, and have been converted into a first-class steel at the Holcomb Steel Works. This steel has been extensively tested and found to be equal in every way to the same grade of nickel steel.

The results of these tests on this new alloy have attracted the attention of the steel makers, and it was somewhat of a surprise to them to learn that the presence of copper in a steel which had heretofore been considered harmful, and was particularly guarded against by purchasers, was now found to be bene-

¹ Written by H. A. Fournier.

ficial. Furthermore, recent experiments both in Europe and in the United States have proven beyond doubt that copper combined with nickel in certain proportions replaces the nickel, and is not only not injurious, but imparts valuable properties to the product. Burgess has demonstrated that copper is capable of replacing nickel in steel, and therefore increases the tensile strength of the alloy.

It is interesting to note that as a result of these experiments some steel makers purchased Monel metal, a combination consisting approximately of 70 per cent Ni, 28 per cent Cu, and 2 per cent Fe, and used it in place of nickel for alloying the steel. The nickel-copper-steel thus made is to-day used with great success in the United States and Germany, and would have a much wider use if Monel metal could be more easily obtained and at a lower cost. The production of this alloy which has met with such an approval of the steel makers, is accomplished by adding Monel metal to iron obtained from an outside source. It is believed that a more economical treatment could be found, and a more homogeneous alloy would be formed if a procedure were followed in accordance with what was suggested in my address before the Commission of Conservation,¹ when it was recommended that the iron content of the nickeliferous pyrrhotite of the Sudbury ore be not fluxed out as is done at present, but that the roasted nickeliferous pyrrhotite be smelted in the electric furnace to a ferro-nickel pig to be afterwards converted into steel.

The possibilities in this direction, as suggested in this address, have led some metallurgists in the United States to investigate the subject, and efforts are being made by them to acquire properties in the Sudbury region to supply ores for the production of nickel and copper steel alloys by direct process.

The foregoing statements in regard to the character of nickel-copper-steel alloys are supported by certain tests which I have made on three different bars of this alloy, containing different proportions of the three metals mentioned. These bars were supplied to the Mines Branch through the courtesy of Mr. J. N. Colvocoresses, and the tests were made by Dr. H. T. Kalmus at the Research Laboratories of Electro-Chemistry and Metallurgy, School of Mining, Queens University, Kingston, Ontario. The results of Dr. Kalmus's investigation are as follows:—

Report on Copper-Nickel-Steels.

Samples received from Dr. Eugene Haanel, Oct. 1st, 1913.

Analyses and tests made at the Research Laboratories of Electro-chemistry and Metallurgy, Queens University, Kingston, Ontario.

Analyses.²

	<i>Sample I.</i>	<i>Sample II.</i>	<i>Sample III.</i>
Nickel.....	2.52%	1.69%	1.00%
Copper.....	1.01%	0.66%	0.43%
Sulphur.....	0.042%	0.041%	0.045%
Carbon.....	0.453%	0.43%	0.45%
Iron.....	95.95%	97.13%	98.10%
	<hr/> 99.97%	<hr/> 99.95%	<hr/> 100.02%

¹ First Annual Report, Commission of Conservation, 1910, p. 63 and p. 68.

² These analyses are, in each case, the result of duplicate check determinations.

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Hardness Tests.

One face of each of these bars, which were approximately 1 inch square in section and 4 inches in length, was smoothed off, and hardness tests made with a Standard Olsen Hardness Testing Machine.

Hardness was computed in the Brinell system. For comparison, the following table of hardness in the same system is given, as measured at this laboratory, under conditions identical with those for the measurements on the copper-nickel-steel.

Reference Table of Brinell Hardness.

Copper, rolled sheet.....	65.6
Swedish iron.....	90.7
Wrought iron.....	92.0
Cast iron.....	97.8
Mild steel.....	109.9
Tool steel.....	153.8
Spring steel.....	160.3
Self hardening tool steel.....	180.0

Brinell Hardness of Copper-Nickel-Steel Samples.

Sample No. I. Brinell Hardness: 166.

This is the mean of 13 independent observations, with an average deviation from the mean of about 3 per cent.

Sample No. II. Brinell Hardness: 149.

This is the mean of 9 independent observations, with an average deviation from the mean of about 3 per cent.

Sample No. III. Brinell Hardness: 139.

This is the mean of 9 independent observations, with an average deviation from the mean of about 2 per cent.

Turning Properties.

Sample No. I.

This alloy machines freely with a medium long curling chip, having the general turning characteristics of a good quality of machinery steel.

Sample No. II.

This alloy machines freely with a medium long curling chip, and is slightly softer and slightly tougher than sample No. I.

Sample No. III.

This alloy machines freely with a very long curling chip, and is distinctly tougher than either sample Nos. I and II.

Tensile Strength Tests.

Standard 2" test bars were turned, of about 4" over all length. The heads were threaded, and the effective diameter was 1".

Tensile strength measurements were made on a Universal Standard Richle Testing Machine.

Sample	Maximum Tensile Stress	Elastic Limit	Contraction of Area	Elongation on 2'' specimen	Fracture
No. I	110,000 lbs./in. ²	76,500 lbs./in. ²	33.2%	20%	Crystalline.
No. II	91,800 " "	61,200 " "	47.0%	28%	Finely granular.
No. III	85,700 " "	61,000 " "	42.4%	25%	Very finely granular.

Forging Qualities.

Sufficient material was not supplied to make a careful study of the relative forging qualities of these three samples, but a single experiment with the pieces resulting from the tensile strength measurements showed that *all three samples forged with the greatest facility.*

(Signed) H. T. KALMUS.
October 15, 1913.

ESTABLISHMENT OF A CERAMIC LABORATORY.

The completion of the new chemical laboratories of the Mines Branch has made it possible to arrange for an expansion of the work of the Department along lines for which there has been an active demand for some years. It is proposed to establish a Division of Ceramics in connexion with the Mines Branch, and to equip laboratories for testing clays, shales, and other materials used in our various ceramic industries. The following letter, addressed to the Honourable the Minister of Mines, on October 2, 1913, explains the reasons for providing the facilities for this work:—

Ottawa, October 2nd, 1913.

Honourable Louis Coderre, M.P.,
Minister of Mines,
Ottawa.

SIR, —

In the great expansion and development of commercial activities, now so apparent in the Dominion of Canada, the subject of "Ceramics" is necessarily of great importance.

The commercial value of clay products in Canada may be estimated from the following figures, collected through the Statistical Division of the Mines Branch:—

Clay Products Manufactured in Canada during the year 1912.

Brick, Common.....	\$ 7,010,375
Pressed.....	1,609,854
Paving.....	85,989
Ornamental.....	8,595
Fire-clay and fire-clay products.....	125,585
Fire-proofing.....	448,853
Pottery.....	43,955
Sewer pipe.....	884,641
Tiles.....	357,862
Kaolin.....	160
Total value.....	\$10,575,869

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During the calendar year 1905, the importation of clay products into Canada amounted in value to \$2,501,206, and has increased to \$6,592,540, for the year 1912, equal to 163.5 per cent.

For the year 1912, we utilized \$17,168,409 of clay products, yet the returns show that we imported 68 per cent of these products.

This simple statement proves that last year we sent out 6,500,000 dollars from Canada.

If this had been held in our own country, it would have meant the investment of a large amount of capital, and would have given employment to a large number of men.

As early as the year 1904, I gave the subject of "Ceramics", in Canada, special study and consideration, and instructed Mr. J. Walter Wells, B.Sc., of Toronto, to make an exploratory examination of the values of the clays and shales in the province of Manitoba, suitable for industrial purposes.

The object of this special investigation, as set forth in the instructions given to Mr. Wells, was:—

(1) To give an idea of the distribution, character, and chemical composition of the clays and shales of Manitoba.

(2) To give a short account of the brick-making industry in Manitoba, with some suggestions for reducing the cost, and improving the product.

(3) To show further practical uses for the clays and shales in Manitoba.

It was my intention to establish a Ceramic Division, but, owing to lack of facilities for making practical tests and chemical analyses of the clays, etc., the economic side of this subject had to be delayed until we had a proper laboratory, etc.

Four years ago, the Director of the Geological Survey commissioned Professor Heinrich Ries, of Cornell University, Ithaca, U.S.A., assisted by Mr. Joseph Keele of the Geological staff, to make a report on the clay-shale resources of the Dominion.

Reports covering the eastern and western parts of the country have already been issued.

These two volumes have drawn public attention to the ceramic resources of Canada.

While these reports are extremely valuable in locating clay-shale areas, and describing the geological strata where these resources occur, a further investigation of the economic and commercial values of the clays must be determined by duly qualified ceramic engineers, in properly equipped chemical and physical laboratories.

I have had this subject under consideration for some years, and when designing the laboratories for the Mines Branch provision was made for ceramic examinations.

I understand that this subject has been brought to your attention through the application of Principal Falconer of Toronto University, for a grant of money to assist the University in the demonstrative work being carried on in their college laboratories.

I am strongly of opinion that this grant, if given, would not materially help the development of the clay product industry of Canada.

The subject is altogether too important to remain in the hands of any educational institution—the essential functions of which are educational, rather than commercial. The economic determination of the commercial values of clay-shale products for industrial purposes is the special work designed for the Mines

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Branch, and should form an important division of its present laboratories and testing stations, which have already been established in Ottawa.

ESTABLISHMENT OF A TECHNICAL LIBRARY.

Previous to 1913, the Mines Branch had no organized library. In 1908, the staff on the inside service numbered only 7, but in 1912, this number had increased to 34: with corresponding increase in the range and scope of the practical work being undertaken.

And since the methods of science as applied in commerce and industry are constantly changing, owing to new discoveries and inventions, it was deemed necessary, in order that the operations of the technical officers should be up-to-date in every respect, that technical books, magazines, and journals, embodying the latest thought and achievement in applied science, should be at their disposal.

Hence it was deemed advisable to establish a properly equipped reference library of technical books, etc., bearing on the economic work being done by the Mines Branch.

Accordingly, a Technical Librarian was appointed by order-in-council on July 26, 1913.

I have the honour to be,

Sir,

Your obedient servant,

(Signed) EUGENE HAANEL,

Director of Mines.

INDIVIDUAL SUMMARY REPORTS

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METALLIFEROUS DIVISION.

I.

PROGRESS REPORT ON THE MONOGRAPH ON COPPER MINES
AND COPPER MINING IN CANADA.*Alfred W. G. Wilson.*

Chief of Division.

During this year about eight and one-half months have been spent in Ottawa. In addition to work on the report relating to the copper industries of Canada, a large amount of miscellaneous routine work has occupied a considerable portion of the writer's time. The manuscript of the report on the Copper Smelting Industries of Canada was sent to the editor on July 15, and delivered to the King's Printer July 18, 1913. At the close of the year the publication had been advanced as far as page proof; it is therefore probable that the report will be published in March, 1914—an interval of nine months between the date of completion of the manuscript and the publication of the report. Some progress has already been made on the companion report dealing with the Copper Mines and Copper Mining Industry; and it is hoped that this manuscript will be ready for publication before midsummer, 1914.

The writer was absent from the office on field duty for a period of about three and one-half months. This being the year of the meeting of the International Geological Congress in Canada, the writer was in attendance at the session in Toronto as one of the official delegates from the Mines Branch of the Department of Mines. He was a member of the excursion which visited the Sudbury-Cobalt-Porcupine region, before the Toronto meeting. After the general session of the Congress he accompanied one of the transcontinental parties through southern British Columbia; and afterwards went to Dawson with the Yukon party, returning to Vancouver on September 22.

While on these excursions the writer had the opportunity of re-visiting all the important copper mines in British Columbia, and of bringing his notes up to date. On the Yukon excursion a visit was paid to the Pueblo copper mine, which had not previously been visited. The writer has now, in the course of his field investigations, visited every producing copper mine in Canada.

The month of September was spent in re-visiting several important localities along the coast to complete the field notes on Canadian Copper Mines.

Following the completion of this work, the writer, on October 21, in accordance with his instructions, proceeded to Nelson and vicinity for the purpose of obtaining some special information for the Director of Mines, in regard to the need for a Royal Commission to enquire into the conditions of the lead and zinc mining industries. While in Nelson, instructions were received by wire to collect for assay, samples from the principal localities in which it was alleged that platinum, or metals of the platinum group, had been discovered. The report on these samples is appended hereto.

After completing the work in the Nelson district the writer returned to Ashcroft, B.C., where he joined the Provincial Geologist (Mr. W. F. Robertson), on a journey north, as far as Hydraulic and Bullion. The writer's primary purpose was to see for himself some of the occurrences of native copper in amygdaloidal traps which had been reported from this district.

At Ashcroft we were joined by Mr. Howard W. DuBois, General Manager of the Quesnelle Hydraulic Gold Mining Company, who was kind enough to return with us to Hydraulic, and through whose courtesy we were accommodated at the mine camp for several days. Through the courtesy of Mr. Robertson

and Mr. DuBois, each of whom personally guided the writer to places known to them, he was enabled to visit several of the localities in which native copper had been found. Several pounds of native copper, recovered in sluice boxes, were also collected.

Native copper has also been found in the gravels at several points when washing for placer gold. Nearly all the localities are on the Quesnelle or on streams tributary to this river. It has also been found in places in amygdaloidal traps near Hydraulic and near Moffat creek about $4\frac{1}{2}$ miles from Horsefly. Some Chinese miners are said to have worked one of these prospects for a short time, by somewhat primitive methods, and to have obtained some copper which was shipped directly to China. During the past summer an exploratory tunnel, said to be about 100 feet in length, was driven into the scarp along the north side of the Quesnelle river, at a point a little over one mile east of Hydraulic. No ore in quantity is reported. Further details will be given in the complete report. It should be added, however, that concentrations of native copper in quantities sufficient to constitute commercial ores, have not yet been discovered in the district. The quantity recovered in the placer washings is insignificant.

In company with Mr. Robertson, the writer also visited several of the old placer gold localities in the vicinity of Hydraulic and Horsefly. A heavy fall of snow made the trails almost impassable, and rendered it necessary for us to return without proceeding to Barkerville—where most of the placer work is now being done. The writer reached Ottawa on the 3rd of November.

II.

INVESTIGATION OF ALLEGED PLATINUM DISCOVERIES IN THE VICINITY OF NELSON, B.C.

Alfred W. G. Wilson.

In accordance with instructions received at Nelson, B.C., on October 5, 1913, arrangements were made to personally obtain samples from the exact localities at which these alleged discoveries of platinum had been made.

After interviewing several interested parties, it was decided that it would be best for me to visit the following places: Rover Creek, Granite-Poorman mine, and Five Mile, the latter locality being 5 miles east of Nelson, on the south side of the western arm of Kootenay lake. I was accompanied to Rover creek, and the Granite-Poorman mine, by Mr. Thomas Gough, manager of the Granite-Poorman, and by Mr. George Douglas, representing the owners of the Rover Creek location. The visit to Five Mile was made by launch, with Mr. M. R. McQuarrie, Mr. H. W. Robertson, and Dr. Wm. H. Willson, all of Nelson. Dr. Willson acted as guide, and pointed out exact localities from which he stated that the samples containing platinum or metals of the platinum group had been obtained.

Samples were collected by me personally at each of the localities visited, from the places pointed out by my guides as the exact localities from which previous samples, containing the metals of the platinum group, had been secured. It will be noted that in every instance I had a guide to the locality personally interested, and personally familiar with it, and, therefore, it is to be assumed that my samples were all obtained from localities best likely to show the results desired by all the interested parties whom they represented.

In all, 17 samples were collected, with the usual precautions. Ten of these samples have been sent for assay, as follows: three from Rover Creek, five from two places in the Granite-Poorman mine, and two from Five Mile. One of these latter was from the so-called Patenaude dike, the other from the Devlin dike. In addition, a sample of a special lot of concentrates from the Granite-Poorman mine was obtained through the courtesy of Mr. Thomas Gough.

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Rover Creek. The rocks seen at all the points visited in the valley of this creek are mica schists. They carry a good deal of iron pyrites, and are often stained with iron rust as a consequence. The rock probably owes its metamorphic character to the presence of the Nelson batholith, which outcrops on the east side of Rover Creek. No dikes occur in the immediate vicinity of the localities pointed out, as those from which samples containing platinum had been obtained.

Granite-Poorman Mine. Two localities in this mine were visited under the guidance of Mr. Gough, and samples were taken from both places. One of these was the so-called granite dike in the Beelzebub drift on the fifth level—the original locality of the alleged discovery of the occurrence of metals of the platinum group. Two samples were obtained from this point by me. Some time previously a lot of 65 tons of material was taken from this same place, and treated in the concentrating mill, yielding three tons of concentrates—according to a personal letter received from Mr. Gough—the manager. A sample of these concentrates was furnished me by Mr. Gough, for assay. No dike occurs in this locality. The cross-cut from which the material was obtained is driven along a fault zone, which cuts one of the veins on Granite-Poorman property. The drag material from this vein can be found among the more or less decomposed materials of the fault zone. The larger portion of the materials in this fault zone consists of crushed country rock, the feldspar constituents of which have become kaolinized.

The second locality from which the samples were taken is on the sixth level, about 450 feet from the entrance. Here a slip occurs and a short drift has been driven along it. At this point also the material is crushed country rock, containing a small amount of drag from the vein on which the drift was driven. No evidence of the occurrence of any dikes in the immediate vicinity of the slip was seen.

It will be noted that neither in the original locality, nor in the other places visited in this mine, did the writer see dikes of any kind. Both localities are shear zones.

Five Mile. Under the guidance of Dr. Wm. H. Willson, two dikes, known respectively as the Patenaude dike and the Devlin dike, were visited. These dikes appear to be ordinary diabase dikes, and show very characteristic spheroidal weathering. The Patenaude dike has a width of about 33 feet, and the Devlin dike, which occurs some 500 feet farther east, is about 15 feet in width. Samples of the partially decomposed rock, and of undecomposed cores were obtained from each.

The assay report received from the laboratory of the Mines Branch shows that none of the samples collected by myself contained any of the precious metals. The sample of concentrates, each pound of which represented 21.67 pounds of original material in a single lot of 65 tons, showed only 0.87 ounces of gold to the ton of 2,000 pounds, and no platinum or metals of the platinum group.

It is almost needless to state that, under the circumstances, taking into consideration the fact that every opportunity was given to the interested parties to point out the exact localities from which the best samples had previously been obtained, I can see no reason for believing that metals of the platinum group occur in the localities visited. Also, I have seen no evidence to show that they occur elsewhere in the district.

III.

HALL PROCESS FOR DESULPHURIZING ORES.

Alfred W. G. Wilson.

One of the interesting developments of the year has been the Hall process for desulphurizing ores and for the recovery of the sulphur. If the process

should prove commercially practicable its discovery will be of considerable importance not only to smelting industries which have to reduce to a minimum the amount of sulphur dioxide discharged into the air, but also to consumers of sulphur because of possible lower costs. The laboratory demonstrations and tests appear to have proven satisfactory, and arrangements have been made to test the process on a commercial scale at the plant of the Balaklala Copper Company in Shasta county, California. The patent rights for all countries have been acquired by the Sulphur Syndicate, Limited, an English company. The American patents are to be controlled by the Federal Sulphur Company, New York, and all other patents by the British Sulphur Company. The patents for the United States were issued at Washington on December 30, 1913, and bear the serial numbers 1,083,246—1,083,253, there being eight patents in all, covering not only the process for desulphurizing the ore and producing free sulphur, but also several other related processes and appliances. Mr. Hall has also patented some improvements to be added to mechanically operated multiple hearth furnaces for the purpose of treating sulphur bearing ores by his process (U. S. patent 1,076,763). The Canadian patent corresponding to U. S. patent 1,083,246 has been issued.

Apart from the patent specifications the best account of the process that has yet appeared was published in the *Engineering and Mining Journal* of July 5, 1913, pp. 35–36, the article having been written by the inventor, William A. Hall.¹ The following description is based upon the patent specifications, supplemented in part by extracts from this article.

The process is designed to distil the sulphur contained in the sulphide ores—both the so-called fixed atom as well as the so-called feeble atom—in the form of elemental sulphur with the production of a minimum amount of sulphuretted hydrogen and sulphur dioxide. When the furnace operation is properly adjusted there is substantially no combined sulphur discharged in any compound, such as sulphur dioxide, sulphur trioxide, sulphuretted hydrogen, or carbonyl sulphide. According to Mr. Hall the distillation of both the fixed and the free sulphur as such constitutes the advantage of this process over other sulphur recovery processes. The elimination of sulphur as an oxide, with subsequent reduction, means that a large amount of free oxygen must be disposed of before the sulphur reduction begins. This entails additional expense for reducing agents, and in addition, the heat required in dissociating oxygen combined with sulphur is more than that required for direct distillation.

The direct distillation is accomplished by subjecting the crushed ore to the direct action of a non-oxidizing flame and steam, the ore being agitated. The temperature of the ore should be between 700°C. and 925°C.—the former being the approximate temperature at which the sulphur content of the sulphides is distilled, and the latter the approximate temperature at which the sulphides fuse. To maintain a reducing flame of the desired temperature in the presence of steam, the air is introduced with the fuel under pressure to produce a blow pipe flame, and an excess of steam should be avoided. Preferably the flame is caused to impinge directly on the ore.

If, with sufficient steam present, considerably lower temperatures than those given above—say between 500° and 650° C.—are used, substantially all the sulphur will be converted into sulphuretted hydrogen. If the lower temperature given above (700° C.) be employed, substantial quantities of elemental sulphur as well as sulphuretted hydrogen may be produced. In practice the temperature will be regulated so as to avoid the production of any substantial or detrimental amount of sulphuretted hydrogen. If any is formed it can be decomposed and the sulphur liberated by admitting regulated quantities of air to form sulphur

¹ Chemists Club Building, 50 E. 41st St., New York.

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dioxide, the latter then reacting on the sulphuretted hydrogen to form sulphur and water.

The process of manufacturing sulphuretted hydrogen by admitting a considerable amount of steam so that practically all the sulphur is driven out in the form of sulphuretted hydrogen forms the subject of one of the Hall patents. In this case the temperature is maintained at a point somewhat below the point at which sulphur distils from pyrites, that is below a temperature of about 700°C . The method of recovering free sulphur from sulphuretted hydrogen by admitting the theoretically equivalent amount of sulphur dioxide in accordance with the equation $2\text{H}_2\text{S} + \text{SO}_2 = 3\text{S} + 2\text{H}_2\text{O}$ is also covered by patent. In this case the reaction is promoted by the presence of sulphur vapor and a small amount of steam.

With reference to the process for recovering elemental sulphur, Mr. Hall states that the rate of decomposition in the Hall process, when conducted in multiple-hearth furnaces, appears to be from 100 to 125 pounds of ore per square foot of hearth area, per 24 hours. The action is more rapid if the desulphurizing is not carried down to so sweet a roast. The cinder discharged is in excellent condition, comparing favourably with the best obtained by ordinary roasting processes.

Tests have also been made abroad to determine how complete a desulphurizing could be produced by this process and many analyses show less than 1 per cent of total sulphur remaining in the cinder.

Experiments have been made with a large variety of ores, including pyrites, various pyrrhotites, copper concentrates, crude zinc blende, zinc concentrates, and even chemically pure iron sulphide. The action appears to be the same on each, the only difference being in the amount of sulphur discharged, which depends upon the amount contained in the product treated. In order to prove that the "fixed" atom of sulphur is removed by distillation the experimental furnace has been operated on chemically pure iron sulphide. Neither sulphur dioxide nor sulphuretted hydrogen were discernible in the discharge, only yellow elemental sulphur vapor.

The analyses of the cinder show it to be a mixture of the two oxides of iron, Fe_2O_3 and Fe_3O_4 .

If producer gas is used as a fuel, a larger amount of extraneous water is found necessary than when a gas is used that is high in hydrogen, such as water gas, and particularly oil gas. Gasified oil appears to be an ideal fuel, containing substantially no nitrogen, and having extremely high thermal values (B. T. U. over 1,500 per cubic foot).

When high grade fuel oil is used there is a much smaller volume of fumes to be handled in the subsequent sulphur extraction. Where a gas is used that is high in carbon monoxide, a certain amount of carbonyl sulphide is formed, as carbon monoxide has a greater affinity for sulphur at elevated temperatures, but it has been found that when carbonyl sulphide and water vapor pass to a lower temperature (say less than 400°C .) there is a mutual decomposition with the formation of sulphuretted hydrogen and carbon dioxide.

Although the reaction is somewhat exothermic, no allowance has been made for the same in the fuel calculations, the fuel required being calculated as if the reaction were entirely endothermic. On this basis, allowing simply for radiation and for the largest factors of safety, the amount of coal fuel required (gasified) is calculated at less than 10 per cent of the weight of the ore.

The fumes coming from the furnace are of a heavy yellow appearance with no appreciable odour, other than that of hot elemental sulphur vapor. The sulphur is extracted from the fumes by simply washing, it being found that this finely divided elemental sulphur has great physical affinity for water, due, p

sumably, to surface tension. When the fumes are agitated with water, the gases are almost instantly clarified, the sulphur settling to the bottom of the apparatus. Any of the well known gas-washing apparatus, such as the Thiesen or the Feld system, is considered as well adapted for the purpose and tests have been made with them. The fumes have also been run through the Cottrell electrical dust collector, which completely precipitated the sulphur therefrom.

The solids precipitated from the fumes by washing have been analyzed several times and found to run from 98 to 99.5 per cent sulphur; the impurities were sulphides of lead and zinc. The refined sulphur has been found to be over 99.5 per cent soluble in carbon bisulphide.

Mr. Hall also states that some eminent American engineers have calculated the cost of producing sulphur by this method in American smelting works, and have placed it at from \$3 to \$5 per ton.

IV.

IRON ORE OCCURRENCES IN CAPE BRETON.

By E. Lindeman.

The summer of 1913 was devoted to an examination of a number of reported iron ore occurrences in Cape Breton. Twelve localities were visited, and topographical and magnetometric surveys were made of the following properties:—

Glencoe mine, Inverness county.

McPherson mine, Cape Breton county.

Ingraham mine (topography only), Cape Breton county.

Grand Mira property, Cape Breton county.

In this work the writer was ably assisted by Mr. A. H. A. Robinson of the Mines Branch. The last month of the field-season was spent in mapping the iron ore deposits at Arisaig, in Antigonish county.

Numerous occurrences of iron ore have been found in various localities throughout Cape Breton. They consist of hematite and magnetite. Hematite is the most common type, and is generally found associated with the lower Carboniferous series, occupying irregular fissures and cavities in these rocks. It also occurs in the older series, near their contact with the Carboniferous formation. Thus, on the Curry property, a few miles southeast of Boisdale, a small deposit of hematite, of excellent quality, lies in crystalline limestone of Pre-Cambrian age, while on the Ingraham property, near Barachois, specular hematite and limonite occur along the contact of limestone and slate of Cambrian age, occupying irregular fissures and cavities in these rocks. In both cases Carboniferous conglomerate is found to overlie the iron-bearing series in the immediate vicinity of the ore bodies, and there is good reason to believe that the deposits have been formed by deposition of iron oxides, carried downward by surface waters from above lying Carboniferous rocks, which are generally found stained reddish by the presence of a small percentage of hematite.

Owing to their irregular and pockety character, most of the hematite occurrences visited are not considered to be of economic importance. From the Ingraham property a few hundred tons of ore have already been extracted, and a limited amount of ore may yet be taken from this area, favorably situated as it is in regard to shipping facilities; but that the property should ever become a producer of importance does not seem likely.

In Cape Breton, occurrences of magnetite are not common, and where found, as at Upper Glencoe, Barachois, and Grand Mira, their extent has been proved, by magnetometric survey, to be very limited. At Upper Glencoe, the magnetite occurs in small detached masses or lenses along the contact of Pre-Cambrian limestone, and a basic granite. The same conditions exist at Barachois, on the McPherson property. Both these deposits are typical contact deposits. At Grand Mira, on the other hand, the magnetite is found in narrow bands, associated with slates and quartzites of probably Cambrian age. Here it grades imperceptibly into hematite, and is undoubtedly of the same origin as the latter, that is, vein fillings or incomplete replacement of the stratified rocks by iron oxides.

In none of the above mentioned localities has the magnetite been found in such a quantity as to render it of economic importance.

Upper Glencoe.

In 1912, occurrences of magnetite were discovered on the farms of Hugh and John McEachern, situated about one mile southwest of Upper Glencoe post office, Inverness county. They lie up in the Craignish hills, at an elevation of about 500 feet above sea level, and can be reached by wagon road from River Denys or Orangedale stations, on the Intercolonial railway, the distance being 12 and 14 miles, respectively.

During the last two years, considerable trenching and test-pitting has been done on these properties, and at the time of the writer's visit in May, 1913, an inclined shaft was being sunk by the Dominion Iron and Steel Co., in order to test one of the ore bodies. The shaft had a depth of about 60 feet along the incline, and was reported to have been started in ore, but passed into granite at a depth of 28 feet.

The area being heavily drift covered, natural exposures are entirely wanting, and the only opportunity of studying the rock formation is in a few trenches, where it has been exposed, and shown to consist of Pre-Cambrian limestone, in contact with granite.

The magnetite occurs along this contact in several steeply dipping lenses, lying one after the other, in a north and southerly direction; but judging from the magnetometric survey¹ the ore bodies are very small and irregular, and are not considered likely to be of economic importance.

The following analysis represents a sample taken by the writer from the stock pile near the main shaft:—

Fe.....	49.40 per cent
SiO ₂	12.18 " "
Al ₂ O ₃	1.66 " "
CaO.....	7.55 " "
MgO.....	1.88 " "
S.....	1.168 " "
P.....	0.003 " "

The exploration work carried on by the Dominion Iron and Steel Co., on these properties, has attracted considerable attention, and practically all the surrounding land has now been taken up by various parties in search for iron ore. So far, however, no discovery has been made on these newly acquired land areas.

Skye Mountain.

At the head of St. Patrick channel, an offshot of Great Bras d'Or lake, to the west, Skye mountain forms the east end of the Craignish hills. Occurrences of iron ores have been found in various places on the slopes of this mountain, but exploration work carried on here by various parties has failed to reveal any ore body of economic importance. At Iron Brook an irregular filling or impregnation of magnetite and hematite in quartzite has been exploited by means of three tunnels. The two upper tunnels cut a very small irregular body of ore, while in the lower tunnel no ore was met with.

The ore is, as a rule, of low grade, being associated with a considerable amount of quartzite, and contains a large amount of iron pyrites.

Whycocomagh.

The village of Whycocomagh is situated at the head of St. Patrick channel, about 8 miles by road from Orangedale station on the Intercolonial railway,

¹Magnetometric map can be obtained by applying to the Director of Mines Branch.

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about 1.5 miles north of Whycomomagh. Occurrences of iron ore have been reported at Campbells brook, but they are of no economic importance, being merely Pre-Cambrian limestone, which here and there is impregnated with grains of magnetite or ferruginous silicates, chiefly hornblende.

Logan Glen.

At Logan Glen, 5 miles east of Whycomomagh, specular hematite occurs, occupying irregular fissures in Lower Carboniferous conglomerate, none of which exceeds 4 inches in thickness. This area is of no economic value as an iron ore producer.

McPherson Mine.

The McPherson mine is situated about one mile east of Barachois siding, on the Intercolonial railway. The distance by rail from Barachois to Sydney is 21.7 miles.

The workings lie on the Boisdale hills, at an elevation of about 470 feet above the sea level, and immediately north of the road leading from Boisdale to Leitch creek. They consist of three shafts and a number of excavations which expose crystalline limestone and schists of Pre-Cambrian age, with intrusions of granite and greenstones. The only place where the ore is exposed is in the open cut near the road where a few small stringers and patches of magnetite can be seen in the limestone. The principal mining operations have taken place at shafts No. 1 and No. 2. Shaft No. 1 is sunk on an incline into the hillside, while No. 2 is vertical and has a depth of 20 feet. Both these shafts were filled with water at the time of the writer's visit. Shaft No. 3 has a depth of 32 feet and has been sunk on the contact of crystalline limestone and greenstone. No ore is visible in this shaft. The magnetic attraction¹ is confined to a very small area around shafts Nos. 1 and 2, and gives no encouragement for finding any ore body of economic importance.

A sample taken from a small stockpile near shaft No. 1 gave the following analysis:—

Fe	58.10	per cent
CaO.....	0.35	" "
MgO.....	6.90	" "
Al ₂ O ₃	1.92	" "
SiO ₂	6.82	" "
P.....	0.004	" "
S.....	0.500	" "

The Ingraham Mine.

The Ingraham mine is situated about 2 miles southwest of Barachois, at an elevation of about 300 feet above sea level. The Intercolonial railway passes the workings, within a distance of about 2,000 feet.

In 1900, some 500 tons of ore are reported to have been shipped from this property to the Dominion Iron and Steel Company, Sydney. Work was resumed in 1906 by the Nova Scotia Steel and Coal Company, which operated the mine under lease for a short time.

¹Magnetometric map can be obtained by applying to the Director of Mines Branch.

The ore consists of hematite which occurs along the contact of Cambrian slate and limestone, occupying irregular fissures and cavities in these rocks. Small masses of compact rich hematite are often found embedded in the country rock; but the greater portion of the ore is a mixture of hematite, ochreous material and slate. The average iron content of the ore is, therefore, rather low, and the shipment made to Sydney in 1900 is reported to have averaged about 44.4 per cent; while 33.2 per cent is given as an average of the ore from one of the pits operated by the Nova Scotia Steel and Coal Co.

A sample taken from an ore dump near the main shaft gave the following analysis:—

Fe.....	48.70	per cent
SiO ₂	4.62	" "
Al ₂ O ₃	1.90	" "
CaO.....	9.25	" "
MgO.....	0.68	" "
P.....	0.065	" "
S.....	0.087	" "

There are several shafts, excavations, and pits on the property, but shafts Nos. 1 and 2 are the only workings which have produced any ore; the other shafts, pits, and trenches exposing limestone and slate, with an insignificant amount of hematite in one or two places. Shaft No. 1 is vertical, and has a depth of 56 feet. It was started in ore, the ore body dipping at a high angle towards the west. South of the shaft the ore body has been stoped out for a distance of 60 feet when it pinched to about one foot. The width of the stope ranges from 5 to 8 feet. The bottom of the shaft is in slate.

Shaft No. 2 is 25 feet deep. It is reported to be connected at the bottom by a drift 160 feet long, with four pits immediately to the north. At the time of the writer's visit, the shaft was filled with water, and the four pits had caved in.

Boisdale Mines.

On the Curry farm, about one mile south of the crossing of the French Vale and Boisdale-East Bay roads, a small deposit of hematite was opened in the seventies, by the late Mr. Morley of Sydney. The distance from the property to Boisdale railway station, on the Intercolonial railway, is about 6 miles.

The ore body lies in crystalline limestone of Pre-Cambrian age, the general strike of which is N. 70°E, dipping vertically, or at a high angle, towards the south. In several places near the ore body a pegmatitic granite is seen to intrude into the limestone, while farther to the south Carboniferous conglomerates overlie the older rocks.

The principal working consists of an open pit, 110 × 14 feet, from which several hundred tons of good ore have been taken and piled up nearby. The ore body is reported to have had a width at the surface of from 5 to 9 feet, but pinched out at a depth of 12 feet. Later attempts to find the ore at greater depth by diamond drilling have also failed. About 75 feet northeast of the main working, a small pit and a trench expose limestone, but no ore, and all that can be seen of the ore "in situ," are a few narrow veins of hematite in limestone at the west end of the main pit, ranging in width from 2 to 8 inches.

The ore is a massive hematite of good character, as shown by the following analysis, representing an average sample of the stockpile:—

Fe.....	56.79	per cent
Insol.....	12.75	" "
P.....	0.008	" "
S.....	0.022	" "

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On the farm of P. Campbell, about 3 miles northeast of the Curry farm, and a few hundred feet east of the French Vale road, some prospecting for iron ore has, in the past, been done, but no workable ore body discovered.

Coxheath Hills.

On the southeast flank of the Coxheath hills between Sydney and East Bay, several small pockets of hematite occur at the contact of Carboniferous conglomerate with the Pre-Cambrian rocks. Intermittent attempts to explore some of these occurrences have, in the past, been made at Smiths brook and other localities, but they have so far failed to locate any ore body of economic importance.

Loran.

At Loran harbour, about 3 miles east of Louisburg, occurrences of hematite have been reported by the late Mr. H. Fletcher.¹ "On the farm of L. McLean, on the south side of the harbour, coarse red Carboniferous conglomerate, mixed with red marl, overlies the older rocks. The matrix of this conglomerate sometimes consists of hematite which also discolours the underlying felsites. On the opposite shore at Tulley's large fragments of specular iron ore, brown and red hematite occur in the fields associated with the conglomerate. A considerable amount of trenching and test pitting has proved that the ore does not occur in workable quantity on these properties."

Grand Mira, South.

Some prospecting for iron ore has, in the past, been done by the Nova Scotia Steel and Coal Company, on the farms of Archie and John Gillis, situated about one-fourth of a mile north of the South Grand Mira P.O.

The iron bearing mineral found here is a red hematite, grading, in places, into magnetite.² It occurs in narrow bands interstratified with slates of Cambrian age, which have been closely folded. The general strike of the formation is northeast-southwest, with a steep dip towards the northwest or southeast.

The workings consist of a number of shallow shafts and test pits, showing the width of the various bands of ore to be from 2 to 12 inches.

The following analysis represents a sample taken from one of the ore piles:—

Fe.....	62.08	per cent
Insol	6.60	"
P.....	0.368	"
S.....	trace	

Similar deposits occur on the adjoining farms of L. Gillis and Charles McKinnon. They are, however, all of too small extent to be of economic importance.

Marion Bridge.

On the farm of Donald MacKeigan about 2 miles south of the Marion Bridge P.O., some trenching and diamond drilling have been done in search for iron ore, but evidently with negative result. All that can be seen here are a few narrow bands of hematite, interstratified with slates, and having a width of from 2 to 5 inches.

¹References: Geological Survey of Canada, 76-77, pp. 449 and 480.
Geological Survey of Canada, 77-78, p. 28F.

²Magnetometric map can be obtained by applying to the Director of Mines Branch.

Loch Lomond.

The lakes of Loch Lomond lie in the southwestern part of Cape Breton county and extend into Richmond county. They occupy a lowland of Carboniferous rocks which themselves lie between Devonian rocks to the west and Pre-Cambrian to the east. On the farm of John McVicar, about 1.5 miles south of Enon post office exploration work, carried on by the Dominion Iron and Steel Company, has exposed some hematite associated with Carboniferous rocks near their contact with syenite of Pre-Cambrian age. Judging from the material taken from the workings, the ore occupies irregular fissures and cavities in the Carboniferous conglomerate.

A picked sample from one of the ore piles gave the following analysis:—

Fe.....	62.1	per cent
Insol.....	9.7	"
P.....	0.007	"
S.....	0.030	"

On the farm of D. McIntyre, about one mile south of the McVicar farm, similar occurrences of hematite have been exposed by a number of test pits. They occur in Carboniferous conglomerate and sandstone. Where exposed, their width is found to range from 2 to 18 inches.

V.

LODE MINING IN YUKON.

*T. A. MacLean.***Introductory.**

I left Ottawa for Yukon on June 13, 1913, to continue the work begun in 1912, upon which I had already reported in part.¹ I returned on January 19, 1914.

My instructions were, specifically, to examine and sample with greater detail, a number of deposits which—when examined in a preliminary manner in 1912—showed promise, if developed, of proving of commercial value; also, in a general way, to overlook new developments, if such existed, in the vicinity of my work.

The properties specially mentioned were: (1) the Humper group of Dail and Fleming, and (2) the Venus mine, both on Windy Arm; (3) the Whirlwind group, and (4) Tally-Ho group, both on Wheaton river; (5) Stewart and Catto; (6) Olive, and (7) Eagle groups—all three on Dublin gulch; (8) Lone Star mine, and (9) Mitchell group, in the Dawson district; and (10) the Big Thing mine,² near Carcross.

Arriving in the field on June 30, I was joined by Mr. Archibald MacLean,³ of Carcross, who acted as my assistant throughout the season. Others, who assisted me for upwards of six weeks at a time, were: David Stevenson, of Carcross, and Henry Detraz, of Coffee creek, both of them old time prospectors or miners, whose services were unstinted.

All the samples taken during the season were assayed for gold and silver or for copper by Mr. Wm. C. Sine, Territorial Government assayer at Whitehorse. Samples from the Windy Arm properties were assayed, for lead, by Mr. H. A. Leverin, under the direction of Mr. F. G. Wait, Chief of the Division of Chemistry of the Mines Branch, Ottawa, to all of whom I wish to acknowledge my indebtedness.

Itinerary.

Six weeks were spent on the Windy Arm properties; the work, in that portion of the field, including a reconnaissance survey of a portion of the ground—measurements being taken chiefly by stadia; and a somewhat extensive sampling of the veins and workings.

On August 14, we proceeded by steamer from Whitehorse to Dawson; and, during the last week in August, carried on work at the Lone Star mine.

It was intended to finish work both in the Dawson and Dublin gulch districts before the freeze up, and then to return to the south end, in order to overtake the work on the properties mentioned, in Wheaton, and in the vicinity of Carcross.

The above itinerary was, however, changed as a result of representations made by Dr. Alfred Thompson, M.P., to the Department of Mines, Ottawa, on behalf of claim owners and others interested in the White River district. For a number of years past, hearsay reports of copper deposits at the head of White

¹ Summary Report Mines Branch, Dept. of Mines, Canada, 1912, pp. 124-139. Also *Lead Mines in Yukon*, by T. A. MacLean, Mines Branch, Canada, 1913.

² This property had not previously been examined, but, on account of extensive development it was recommended as being worth while.

³ On March 1, 1914, appointed Mining Recorder at Carcross, N. T.

river had been brought in by prospectors, who were, generally, working under grub-stake agreements with parties in Dawson and elsewhere. Considerable money, amounting in the aggregate to many thousands of dollars, was, from time to time, supplied for the prosecution of this work. In 1905 Mr. R. G. McConnell examined the district, and made a report. In 1908¹ Messrs. Moffit and Knopf of the United States Geological Survey, reported on the Nabesna White river district, Alaska; a portion of their report, dealing with the occurrence of copper on the Canadian side, being quoted in the Summary Report of the Geological Survey of Canada for 1909.²

Glowing accounts of new finds of both copper and gold continued to be circulated each year,³ until finally, in 1913, it was suggested, by parties interested, that the Dominion Government should be asked for assistance in the construction of a railway to open up that country.

In order, therefore, that the Government be placed in possession of more definite information as to the probable economic value of the ore bodies which were reported to have undergone some development, I was instructed to proceed to the head of the White river, and make the necessary examinations.⁴

This trip was commenced from Dawson on September 6 and occupied two months. The route adopted was via Coffee Creek trail,⁵ by means of a pack train⁶ comprising four horses.

The properties visited in White River district are located, chiefly, in the vicinity of Canyon City; also in the area lying between White river and Beaver creek, for a distance of 15 or 16 miles, in a northerly direction from Canyon City.

The latter is situated on the left limit of White river, between 125 and 150 miles from its entry into Yukon river. The trail overland from Coffee creek was, at the time, very bad, entailing much hardship on the horses. They were required either to wade knee-deep through miles of swampy ground or stretches of muskeg and niggerheads, or again to ford, or swim, swift running rivers filled with ice; and this at a time when feed was difficult to procure because of the frozen condition of the soil.

Before completing the above trip, winter had settled down on the Territory, and, though some work was afterwards undertaken at Dublin gulch, it was found necessary to curtail it, and to omit entirely that in Wheaton river district.

Galena creek, a tributary of McQuesten river, 11 miles off the road to Dublin gulch, was, however, visited as a result of the reported find of a rich argentiferous galena vein. This was of much interest, as indicating a variety of deposit not hitherto exhibited on any of the areas previously examined in this district.⁷ Reports were, to some extent, confirmed by assays of samples sent by the owners to the Territorial Government assay office in Whitehorse. Representatives of the owner were found actively at work on the property and such data as development permitted, was secured.

Sampling.

During the season, 529 samples, in the aggregate, were secured from the various properties visited, the greater number coming from the Windy Arm district.

¹ Summary Report Geol. Survey, Canada, 1905, pp. 19-26.

² Summary Report Geol. Survey, Canada, 1909, pp. 23-26.

³ See also MacLean, T. A., *Lode Mining in Yukon*, Appendix I, Mines Branch, Canada, 1913.

⁴ Cairnes, D. D., of the Geol. Survey, Canada, was engaged during the seasons of 1912 and 1913 mapping geologically a portion of this district, and is now preparing his report which will doubtless touch upon these same deposits.

⁵ See also Chisana Goldfields, by D. D. Cairnes, Bulletin 24, No. 14, pp. 43-45, Can. Min. Inst.

⁶ In this connexion I wish to acknowledge indebtedness to Mr. H. F. J. Lambert, of the International Boundary Survey, for kindness in allowing me the use of a horse, and other necessary outfit.

⁷ See *Lode Mining in Yukon*: T. A. MacLean, Mines Branch, Canada, 1913, pp. 130-134.

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In calculating money values of the assays, the following prices were adopted:—

Fine gold \$20.00 per ounce.

Silver 0.60 “ “

Lead 0.021 per pound.

During the year 1913 New York prices fluctuated as follows:—

Silver between $56\frac{7}{8}$ and $63\frac{3}{4}$ —the average being 59.791c. per oz.

Lead “ 3.95 and 4.75—“ “ “ 4.37c. “ lb.

The price 2.1c. (\$0.021) per lb. for lead, used in calculating assay values, is the approximate net value when duty and smelter deductions of 2.25 off New York average price is allowed for.

Summary and Conclusions.

Windy Arm.

Results of more detailed sampling on the Windy Arm properties are not as good as the preliminary sampling in 1912 led me to anticipate.

In the case of the Humper properties, with, however, very limited development, where the mine run averages in gold and silver from \$5.29 up to \$13.84, the ore may be sorted, and the selected ore raised to \$50.00 or more per ton and this would admit of being shipped outside for treatment. Water freight from Windy Arm, 16 miles to Carcross, on any considerable tonnage of ore, should not exceed \$1.50 per ton. From Carcross to Skagway, by White Pass and Yukon route, the freight on sacked ore is \$3.50 per ton, carload lots. An additional \$1.50 would land ore at one of the coast smelters, i.e. \$6.50 per ton as a total freight charge, and this amount would probably admit of reduction by special arrangement with the White Pass and Yukon route for through transportation from mine to smelter.

With regard to the Venus property it is apparent that the average value of ore over the greater portion of the deposit sampled is of too low a grade to be mined with profit under present conditions because of the high cost of labour and transportation. There is, however, a limited tonnage of pay ore in certain of the stopes which may be won at a profit by economical mining.

Conditions as to sorting and transporting ore are similar to those for the Humper group above referred to. It is claimed that, while the Venus mill was operating, a considerable proportion of the silver was lost in the slimes. An objection to the mill-site is its proximity to the water, which does not permit of room for tailing dump; the latter would necessarily become submerged.

The following is the wage schedule which maintained during operation of this property¹:—

Miners and	}	\$3.50 per day and board.			
Machine men					
Blacksmith		4.00	“	“	“
Carpenter		4.00	“	“	“
Foreman		5.00	“	“	“

The estimated allowance for board is \$1.50 per day.

Lone Star Mine.

In case of the Lone Star mine near Dawson, during the past two seasons, 1912 and 1913, sampling and assaying have indicated the average value of ore to be under \$1.00 per ton. The mill has, notwithstanding, handled 6086 tons, and won \$19,803.86.²

¹ Figures supplied by Mr. Archibald MacLean of Carcross.

² This is vouched for by the Company's annual statements for 1912 and 1913.

The history of operations on this property during the past two years, indicates that more extensive development is warranted.

Only by operating on a large tonnage basis is it possible to work such low grade ore at a profit. The estimated possible margin of profit¹ is so small for the portion of the deposit which the mill may be considered to have proven, that before the company endeavours to greatly increase its mill capacity, the present mill should be used to test material over a greater extent of the deposit. If the average results obtained are then as good as those for the past two years, expenditure on plant sufficient to handle several hundred tons of ore per day would be justified.

Dublin Gulch and Galena Creek.

In case of the few Dublin gulch properties, from which additional samples were secured, namely, Stewart and Catto, Olive, and Shamrock properties, some good values are found in each case.

The average tenor secured from the more developed parts of workings, however, is still below requirements for mining on any commercial scale. Development is, as yet, too limited to warrant any very definite conclusions other than that continued work is advisable.

For the small amount of development on Galena creek the property appears to be one of promise.

White River District.

The discovery of a large copper nugget, together with smaller slabs and bunches or stringers throughout the amygdaloid country rock, was a strong incentive to the prospectors to continue work in the hope of locating a great body or mother lode. So far as the properties which were heralded as of first importance are concerned, the discovery appears to be limited to a few tons of cupriforous material from stringers, besides a low grade copper—from traces up to 0.85 per cent, throughout portions of the country rock, in addition to the first noted find.

In connexion with the development of a copper mining industry in this district, it is essential that a deposit, or group of deposits in the aggregate, be sufficiently large to warrant the building of a railway and smelter. Amygdaloid ores of this character are reported to have yielded, in certain years, the larger proportion of the copper production of Michigan,² the average value being 0.88 per cent.

Notwithstanding the many reported rich finds over a very large territory, and the superficial evidence that, in places, for miles of country along the upper stretch of the White river, the country rock gives the impression of being copper stained, no definite vein or lode system of commercial value has yet been developed.

No development of any consequence was noted in connexion with the few gold or silver prospects it was possible to visit in this district.

The White River district is of wide extent, and though it may be said with truth that the more recent current reports of the richness of the copper deposits have been misleading, and that an exaggerated conception of the prospects has been harboured by a majority of residents in Yukon, yet it would be unwise to make a sweeping condemnation of the district.

The recent discovery of gold in Chisana, Alaska, has revived interest in the White River country, which is assured a pretty thorough investigation during the coming season, and though interest centres chiefly in placer gold prospects, the possibility of locating lode deposits is not being entirely overlooked.

¹ Cost of winning the gold for 1913 is \$3.52, which includes interest and all charges. See Annual Statement.

² Mineral Deposits Lindgren, pp. 402-403.

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NON-METALLIFEROUS DIVISION

I.

INVESTIGATION OF THE CANADIAN MARKET FOR VARIOUS
MINERAL PRODUCTS IN A CRUDE, OR PARTIALLY
PREPARED STATE.*Howells Fréchette.*

Chief of Division.

The greater part of the year was devoted to the gathering of final data, and the compilation of the material for the report on non-metallic minerals used in the manufacturing industries of Canada. The report will contain a series of tables showing the quantities of minerals, both domestic and imported, used in each industry, as reported by the consumers, the quantities used in the various sections of the country, Canadian production, and imports. It will include, also, brief descriptions of the economic minerals, the uses to which they are put and notes on the trade requirements of each mineral for its different uses.

It may be pointed out, here, that, as a result of information gained in the above investigation, it has been decided to make a thorough examination of the sands suitable for industrial purposes, and of the limestones in the Province of Quebec. This work will be taken up during the field season of 1914.

Throughout the latter part of July, August, and the early part of September, the writer officially attended the Twelfth International Geological Congress. He was in attendance at the meetings in Toronto, and accompanied four of the excursions.

II.

WHITE MICA OCCURRENCES IN THE TÊTE JAUNE CACHE
AND BIG BEND DISTRICTS OF BRITISH COLUMBIA.*Hugh S. de Schmid.*

A considerable portion of the summer was taken up with business connected with the International Geological Congress, the Session of which I attended as one of the delegates of the Mines Branch. I accompanied, also, various of the excursions organized in connexion with the Congress; both as guide and as assistant secretary. I accompanied transcontinental excursion C 1, in the latter capacity, and on the return journey eastward, left the party at Winnipeg; from which point I proceeded to Edmonton and Tête Jaune Cache, later going south to Calgary and to Revelstoke, in order to secure from the owners particulars regarding the Big Bend mica deposits.

MICA OCCURRENCES NEAR TÊTE JAUNE CACHE.

Notes on the Region.

Tête Jaune Cache (commonly abbreviated to "T. John," and known locally as "Mile 52") lies on the Fraser river, 300 miles west of Edmonton, 52 miles west of the interprovincial boundary, and over 1,300 feet lower on the Pacific slope than the Continental Divide, where crossed by the Grand Trunk Pacific railway at Yellowhead. For the past two years a place of some size and importance on account of being the headquarters of railway construction and the end of steel, the camp is now rapidly dwindling in size and significance. The population has mostly drifted farther west to Fort George, the present rail-head, and within a short while the name Tête Jaune Cache will probably signify merely a station and water tank on the new railway. A regular nightly train service from Edmonton to this point is in operation, the journey occupying about fourteen hours.

The existence of white mica in sheets of commercial size has been known in this district for upwards of twenty years. J. McEvoy, of the Geological Survey, who made a reconnaissance of the region in 1898, records having found a party of miners at work upon claims on Mica mountain while a number of other claims had been staked in the more or less immediate vicinity.¹

These first miners and prospectors came in by way of Kamloops, a distance of over 200 miles, entailing a journey of some three weeks, while about the the same time was taken to get in from Edmonton, 350 miles to the east.

The work commenced at this time has never been prosecuted at all vigorously since, and no serious exploitation of the mica-bearing dikes has ever taken place. The actual operations of the first miners can hardly be termed development work, as the main object seems to have been to collect all the mica in sight, the crystals being contained largely in loose boulders, with which the upper portions of the northwest slope of the mountain are littered. Over a thousand pounds of cut sheets of marketable mica are said to have been secured in this manner, but the then inaccessible location of the deposit was sufficient to discourage any further attempt at systematic mining. Now that the line of the

¹ Geol. Surv. Can., Ann. Rep., 1898, Vol. XI, pp. 80A, 38D.



A

Main street, Tête Jaune Cache, B.C., September, 1913.



B

Mica mountain from railway, one-fourth mile west of Tête Jaune Cache station.
A, Winter and de Witt claim. B, Willson and Swanson claim.

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Grand Trunk Pacific railway passes within a few miles of the claims, fresh interest has been aroused in the possibility of profitably mining mica in this region, and several parties are considering undertaking active development work in the near future. All of the claims are situated in the Cariboo Mining Division, Cariboo District.

Although, as just stated, the railway passes within a short distance of the claims, this must not be understood to mean that the deposits are by any means particularly accessible. The entire series of claims lie either just below the summits, or on the upper slopes of mountains rising to a height of over 5,000 feet

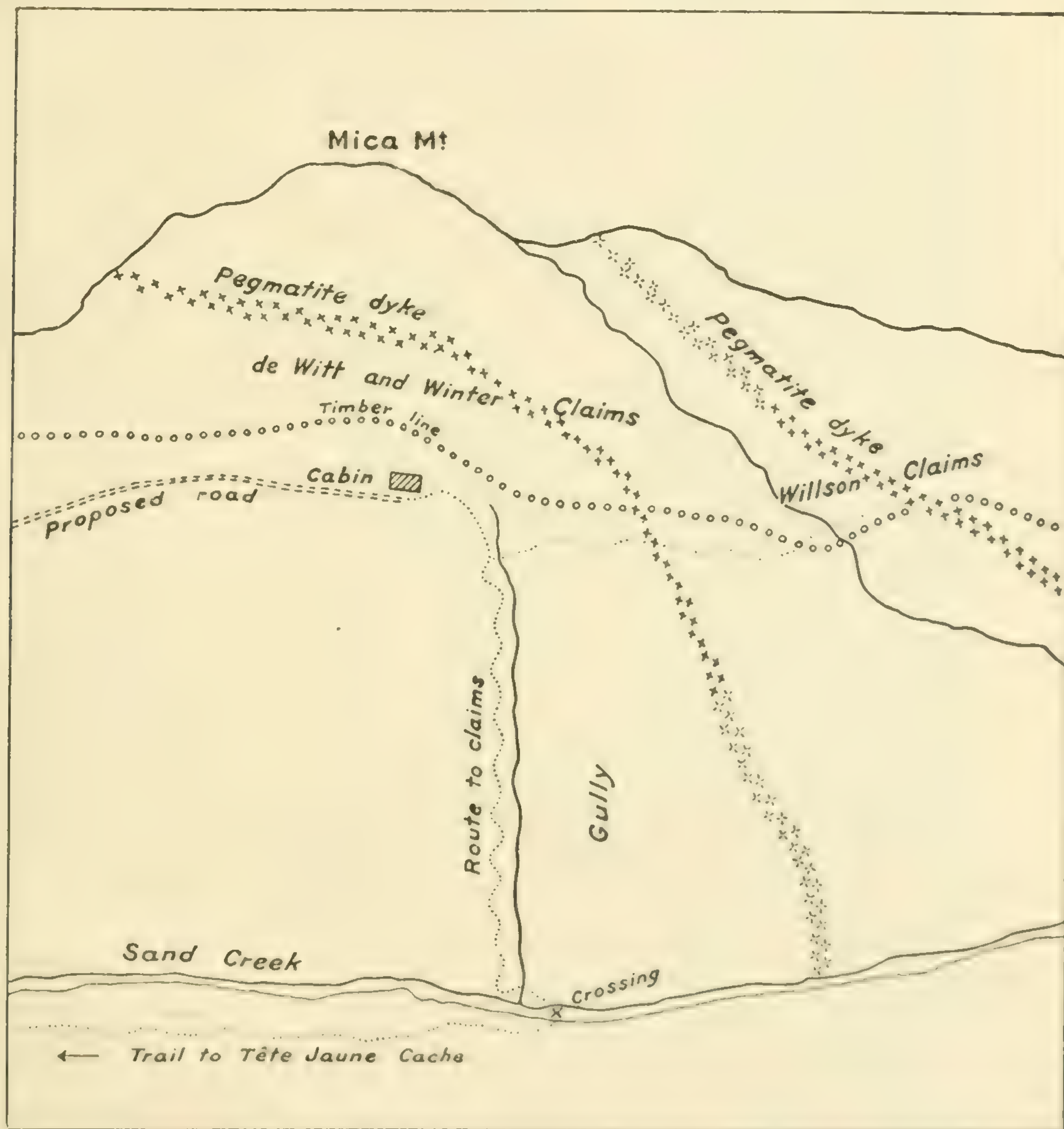


Fig 2. Dikes, claims, trails, etc., in vicinity of Mica mountain, Tête Jaune Cache, B.C. Scale about 2 inches to 1 mile horizontal and about 1 inch to 1600 feet vertical.

above the railway, and at an elevation above sea level of over 7,000 feet. The claims so far located in the immediate neighbourhood of Tête Jaune Cache are situated upon two main mountain masses lying about 5 miles south of the tracks of the Grand Trunk Pacific railway, and approximately equal in height. The more westerly of these two mountains, and that known locally as Mica mountain, consists of a ridge several miles long and separated into several peaks by narrow gullies. The only claims taken up on this mountain are owned by Mr. E. Keller, now (September, 1912) of Mile 142, Fraser river, Grand Trunk Pacific railway.

The claims are two in number and were located in 1910; no active work has ever been carried out upon them, and little information concerning them could be obtained locally.

Directly to the east of this ridge, and separated from it by a deep and narrow gulch, through which runs Sand creek, rises a peak shown on the map as Mica mountain, but known locally as "Nigger's Knob."¹ It is on this mountain that the claims which so far have attracted most notice are located, and from which were taken the already mentioned quantity of sheet mica.

The claims are reached by way of Sand creek, a pack trail existing for part of the distance. South of the railway track the ground rises gently for a distance of about 2 miles, the slope carrying a scattered growth of small poplars and cottonwoods. From here on, the west bank of Sand Creek gulch is followed for about 4 miles, until a log jam is reached, where a crossing can be effected. Sand creek itself is a mountain torrent, about thirty feet wide at this point and containing a considerable volume of water. It is said that the flow is fairly constant during the summer months, and the creek might be used as a source of power in the event of any development of the claims taking place.

South of the crossing point the mountains rise abruptly from the water's edge on both sides of the creek. There is no trail to the claims, and the steep slope is covered with a dense undergrowth of alders, mingled with scattered spruce. The elevation at the foot of this slope is about 1,000 feet above the level of the Fraser river at Tête Jaune Cache, and some 4,000 feet below the claims. These 4,000 feet are ascended in almost a direct line, following the course of a small gully.

The first claims met with by this approach are the Sand Creek claims, owned by Messrs. Thomas Willson and Andrew Swanson. These are four in number, and lie to the southwest of the summit of Mica mountain, just below timber line; they were taken up in 1910.

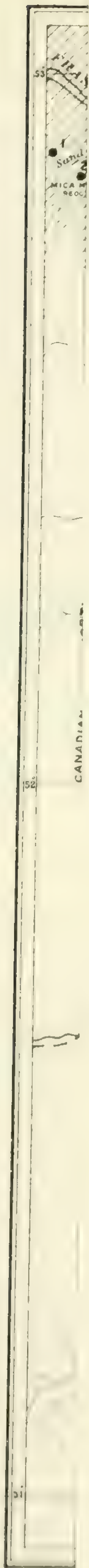
The other claims located on Mica mountain lie east of the above, and at a higher elevation, being partly above timber line and extending up to the base of a steep wall of rock forming the summit of the mountain. These claims, also, are four in number, and were taken up in 1898 by Messrs. F. Winter and J. F. Smith, of Kamloops, who mined for a short time in this year, and about five years ago, it is understood, transferred their interests to a French company. This concern is understood to be controlled by Messrs. de Witt and Winter, and to have its office at 82 Wall St., New York. In September of 1913, while the writer was in the district, it was rumoured that this Company was about to take steps to construct a road to their claims, with a view to undertaking serious mining next season. This road would lead in from Mile 49, 3 miles east of Tête Jaune Cache, and follow the east bank of Sand creek, this route allowing of a grade suitable to transport by motor wagon. While necessitating a considerable initial outlay, the construction of a good road to the claims is a *sine qua non* if any systematic development is to be attempted. At present there is no trail at all for more than half the distance from Tête Jaune Cache, and supplies, equipment, etc., have had to be taken up in packs by the miners themselves, the ground being too rough and steep for horses. The construction of a good road is a perfectly feasible, though somewhat costly undertaking; the distance would be about 7 miles. Timber in abundance, and water, can be had in the immediate neighbourhood of all the claims, and, as already stated, Sand creek could furnish an adequate supply of power to operate a compressor and other machinery.

Messrs. de Witt and Winter have three claims, also, on Canoe river which rises to the south of Mica mountain and flows southeast to join the Columbia

¹ So called from the first claims being taken up by a negro.



Lookout of Sand Creek gulch; view from claims on Mica mountain, altitude about 8500 feet. The precipitous and inaccessible nature of the upper portion of the mountain in this section is well exemplified in this photograph.



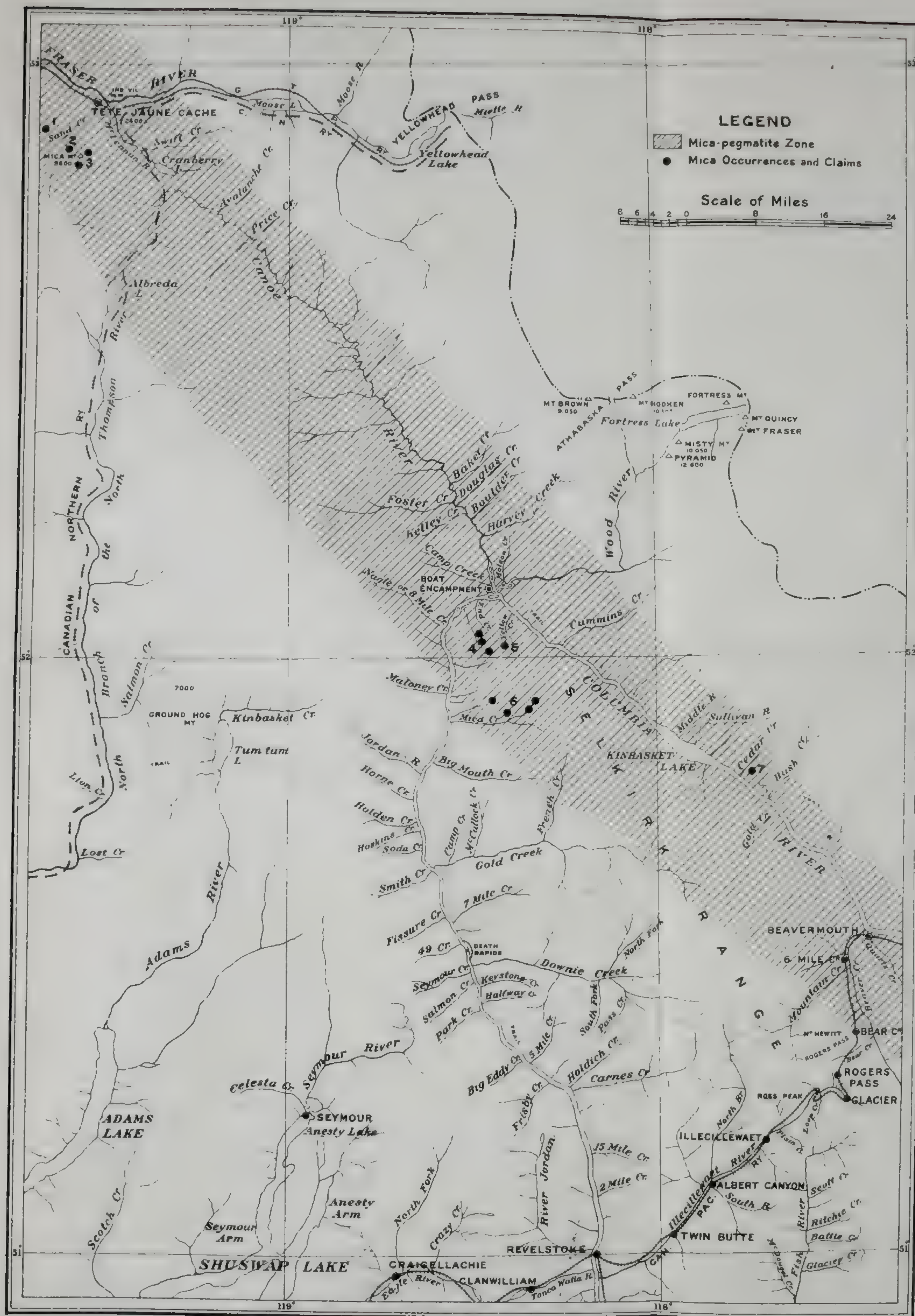


Fig. 3, Map of Mica-bearing district, British Columbia, showing approximate locations of claims and probable area of the pegmatite dike zone

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river at Big Bend; these claims were taken up in 1898, but have never been developed.

On McLennan river, which rises in Cranberry lake and flows north to meet the Fraser river near Tête Jaune Cache, Messrs. Willson and Swanson located four claims in 1910; here, also, no mining has been undertaken.

The above claims comprise the most important mica discoveries made in the Tête Jaune Cache district to date.

It would seem that the occurrence of mica-bearing pegmatite dikes in this section of British Columbia is confined to a zone of rather limited easterly and westerly extent. The mica belt appears to consist of a series of pegmatites intruded in close proximity to one another, and occurrent over a width of not more than a few miles. This series has a northwest and southeast direction, and is probably the same as that encountered in the Big Bend region and, still farther south, in the vicinity of Beavermouth, on the main line of the Canadian Pacific railway. The northerly limit of the series is quite undetermined, and there is no reason to suppose that the dikes terminate in the immediate vicinity of Tête Jaune Cache; it is equally probable that they continue farther to the northwest, and discoveries of mica are quite liable to be made in that section. The country along the route of the Grand Trunk Pacific railway through this section is still virtually unprospected, and the construction of the railway, while rendering possible the development of mineral discoveries, is unlikely, for a considerable time, to promote any extensive prospecting of even that country directly adjacent to its course. The highly indented surface, often thickly covered with scrub, and the short season during which prospecting is at all possible, render operations exceedingly difficult, and are likely to long discourage any thorough exploration of the region.

Geology of the Mica-bearing Area.

While only the claims on Mica mountain were visited, the general occurrence of the mica throughout the entire district (and the deposits in the Big Bend section may be here included also) would appear, from the particulars furnished the writer by the owners and others, to be very similar.

The mica crystals occur in white pegmatite dikes of varying widths, all having an approximately parallel direction and a general trend of N.W.-S.E. The dikes, where exposed on Mica mountain ("Nigger's Knob") probably at no point exceed 100 feet in thickness, though only approximate measurements can be given, owing to many of the exposures being in the faces of precipices. For the same reason, the dip is difficult to determine, but is probably about 35°-50° S.W. The pegmatite is a moderately fine to medium-grained rock consisting of white microcline feldspar, quartz, and muscovite mica. Accessory constituent minerals noticed are red garnet (probably the variety spessartite), and, near the contact with the enclosing mica-schist, biotite mica and prisms of bright blue cyanite. McEvoy¹ notes, also, the presence of beryl, tourmaline, and apatite.

Much of the muscovite present is in the form of small, thin crystals, averaging up to 1" x 1", and only $\frac{1}{4}$ " thick. Small crystals of this type are abundant, and are fairly evenly distributed through the dike mass. The largest crystals seen on the westerly, or Swanson and Willson, claims did not exceed 6" x 4"; but sheets 12" x 8" across were found in loose boulders on the French company's ground. Although weathered and rusty, as surface mica always is, all of the sheets found were clear and free from iron stains and inclusions; in colour they are a brownish-green, and the mica may be said to represent a very fair grade of mineral.

¹ Geol. Surv. Can., Ann. Rep., Vol. XI, 1898, p. 80 A

The rock enclosing the dikes is a series of rusty, highly garnetiferous mica-schists of rather coarse grain, and containing numerous small quartz lenses. These schists have suffered a high degree of crushing and folding, and weather readily to a rusty, friable mass. Local zones are highly charged with staurolite and cyanite, and large crystals of yellowish apatite, up to 4 inches across, were found at one point. The whole system of these schists bespeaks a high degree of dynamic, and, possibly to a lesser degree also, contact metamorphism. The pegmatite dikes were probably intruded prior to, or contemporaneously with, this deformation.

No attempt at mining has been made on any of the claims in the Tête Jaune Cache region, consequently no exposures of fresh unweathered rock could be examined. Some of the freshest sections seen were in the bed and bank of Sand creek. At one such point a band of what appears to be white paragonite schist was noticed intercalated in the normal, darker-coloured series. This system of schists probably forms a narrow belt a few miles wide, having a N.W. and S.E. trend and a dip of some 50° S.W. The series possibly consists of a number of somewhat contorted and elongated lenses, pursuing a course approximately as indicated on the accompanying map, the northerly limit being as yet undetermined.

The mica samples taken at the claims on Mica mountain are of fair quality. Being surface mica, broken out of loose boulders fallen from the dikes, the sheets are necessarily weathered and rusty; this is a condition, however, which affects only those crystals near the immediate surface, and crystals yielding fresh, clean sheets may be expected at a depth of a few feet.

The largest sheets so far encountered come from the de Witt and Winter claims, just below the summit of Mica mountain. A quantity of surface mica could probably be secured here simply by breaking up the large boulders fallen from the dike above. The dike itself could be worked without much difficulty either by a system of adits or by simply blasting out the face. As there is unlimited space for the disposal of waste no means would need to be taken to keep the ground clear.

The first essential, if any attempt at mining is contemplated, is the construction of a road to the claims. Owing to the configuration of the ground at the pegmatite exposures, only the simplest and cheapest mining methods would need to be employed, at any rate for some time. The dike face would, in effect, be blasted out, and the mica crystals broken out of the blocks where they come to rest on the slope. No machines other than power drills would be necessary, as neither hoisting nor pumping would be required.

At this point, as at practically all mica prospects, the only test of the value of the deposits and the amount of mica present is actual development work. The occurrences, from surface indications, would appear to warrant such development, though it cannot be said that indications point to the deposits being other than of average richness. The initial expense connected with their exploitation, and the short season during which transport and work above ground can be carried on, are factors which cannot afford to be lost sight of. The open season, during which approach can be made to the claims and supplies, etc., taken in and mineral brought out, is of about four months' duration, from June to the end of September.

Mica in the Big Bend District.

A number of claims have been staked for mica in the area directly south of the Big Bend of the Columbia river, principally upon the ridges separating Mica, End, and Yellow creeks. This district lies about 70 miles southeast of



A

Photograph by F. Hazard

Near head of End creek. Shows the loose and friable nature of the schists, due to crushing and weathering.



B

Photograph by S. B. Hood

Near head of Mica creek, B.C.

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Mica mountain, and it is most probable that the claims here are located upon southerly extensions of the same series of pegmatite dikes as are met with around Tête Jaune Cache. Similar occurrences have been met with still farther south on the Columbia, and a line joining all three of these locations has very much the same direction as the observed strike of the pegmatite dikes at Mica mountain. Although mica-bearing pegmatites may possibly be found to exist to the west or east of this zone, it is probable that no considerable development of the dikes has taken place at any great lateral distance from the main course as indicated on the accompanying map.

The occurrences of mica in the Big Bend region were not visited, but from information furnished the writer by the owners of claims and by parties acquainted with the district, the deposits are in every way similar to those already described near Tête Jaune Cache.

All the claims are situated in the Golden and Revelstoke divisions, Kootenay district.

Big Bend Mica Company's Claims.

The above mentioned is a syndicate with headquarters at Calgary, Alberta. The number of claims owned is five, the official recording descriptions being as follows:—

Ptarmigan claim: Situated at head of End creek, about $\frac{1}{2}$ mile east of Croup claim and about 7 miles from Columbia river.

Diamond claim: Situated at head of End creek, and $1\frac{1}{2}$ miles northwest of Ptarmigan claim.

Snowshoe claim: Situated at head of End creek, and about 7 miles from Columbia river.

Croup claim: Situated at head of End creek and $\frac{1}{4}$ mile northeast of Snowshoe claim.

President claim: At head of Mica creek, on the north slope of ridge.

The above claims were taken up in 1909, and a certain amount of development work was carried out during the summer of 1910. Over a thousand pounds of untrimmed mica slabs are reported to have been taken out and shipped to Calgary.

The claims can be reached either from Beavermouth—by boat down the Columbia river—or from Revelstoke, from which point a regular weekly steamer service connects with Downie creek, about half way to Big Bend and some 45 miles north of Revelstoke. The former route is seldom used owing to the dangerous character of the river, and the rapids encountered north of Kinbasket lake. From Downie creek a trail exists up the east bank of the Columbia, and ingress with pack train is not difficult during the summer months. The season during which access can be had to the claims, and which represents, also, the period during which mining operations can be carried on, is from July to the end of September. The pegmatite outcrops in this section, as in the Tête Jaune Cache district, are found on the upper slopes or summits of lofty ridges separated by narrow valleys, through which flow, among others, the creeks mentioned above. These ridges attain heights of as much as 7,000 feet, and the claims are difficult to get to. The peaks and ridges at this point form the northerly extremity of the Selkirk range, around which the Columbia flows in a more than right-angled turn.

The mica from the claims in this section is of the same quality and colour as that found farther north, being clear and free from inclusions and stains. Sheets up to $16'' \times 10''$ have been taken out and represent high grade mineral.

Claims of Mr. W. I. Briggs and Company.

These claims, owned by the above-mentioned syndicate with headquarters at Revelstoke, B.C., lie in the same region as those of the Big Bend Mica Company. They comprise three groups of two claims each, and are as follows:

Porcupine claim: Situated near the head of End creek, on the east side of, and about 6 miles from the Columbia river.

Fisher claim: Adjoins the Porcupine claim to the northwest.

Bear Paw claim: Situated at the head of a small creek entering the east fork of Mica creek and adjoins the Eagle Bluff claim.

Eagle Bluff claim: Situated at the head of the east fork of Mica creek and on the north side, about $2\frac{1}{2}$ miles from the forks.

Rainbow claim: Lies on the north side of the northeast fork of Mica creek, 2 miles from the forks and about 9 miles from the Columbia river.

River View claim: Situated at the head of a small creek on the north side of Mica creek, and about 7 miles from the Columbia.

No mining has been carried out on these claims, but sheets of mica up to $15'' \times 10''$ have been found at the surface.

McCarter Claim.

Mr. G. S. McCarter, of Revelstoke, has one claim in this region, namely,

Mica Queen, situated 12 miles from the Columbia river, and opposite the mouths of Canoe and Wood rivers, near the divide between East and West Kootenay.

Here, also, only a small amount of prospecting has been done, but over a thousand pounds of untrimmed mica are said to have been secured in 1901 from surface float, the sheets attaining dimensions of $4'' \times 9''$. The claim is reached by way of Yellow creek.

Systematic development of any of these claims is out of the question until access is rendered less difficult and expensive. At present, horses, supplies, etc., have to be taken by steamer to Downie creek, a distance of some 40 miles, and from here about 30 miles of trail have to be negotiated before the creek valleys are reached. Since the claims are, in most cases, located at a distance of some 10 miles up these valleys, the construction of roads from the Columbia to the claims would be necessary if any heavy supplies are to be taken in, or any great quantity of mica brought out. There is considerable agitation to have a Government road built along the line of present trail up the river; this would facilitate and cheapen transport to some extent, but no small expense would still have to be met in order to establish ready communication with claims situated at a distance of some 10 miles from such a road and at an altitude of 7,000 feet. The present market price of \$2.00 – \$2.50 per pound for the larger sizes of clear sheet mica hardly seems sufficient inducement for such expenditure unless an unusual quantity of large-sized mica is present in the dikes. The general experience in other regions where mica is found is that little more than from 3 to 5 per cent of the total production of a mine is of dimensions exceeding $4'' \times 6''$; the greater part of the output consists of the smaller grades $1'' \times 1''$ to $2'' \times 3''$, which do not fetch more than 25 to 45 cents per pound.¹

Claims of Messrs. Peterson, Richardson, Calder, and Reddick.

The above parties, of Calgary, own three claims on the Columbia river, 25 miles north of Beavermouth, on the Canadian Pacific railway. The claims lie about one mile east of the river, at an elevation of about 800 feet above the valley.

¹ For more definite particulars regarding the development of mica deposits see Report No. 118, "Mica: Its Occurrence, Exploitation and Uses," issued by the Mines Branch, Department of Mines, Ottawa.

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The original discovery of mica at this point dates from the early nineties, but no serious mining has ever been undertaken. The owners report a small amount of development work during 1912, but no mica has been shipped. The locality is reached by boat from Beavermouth, and trail to the claims, the round trip occupying about three days.

The occurrence is reported to consist of three narrow vertical pegmatite dikes about 3 feet wide and carrying mica crystals up to 12" across. The mica is clear and unstained and of a greenish-white colour. The strike of the dikes is N.W.-S.E., and the enclosing rock is a soft mica-schist. The leads are close together, being respectively 4 feet and 9 feet apart. A drift 50 feet long by 5½ feet high has been run in on the main lead.

It may be mentioned that boulders of mica-bearing pegmatite have been found south of the Canadian Pacific railway, and east of Beavermouth, which may be taken to indicate that the dikes extend still farther to the south than has, as yet, actually been determined. Near Mitikan siding, 21 miles west of Revelstoke, a number of pegmatite dikes and stringers are to be seen cutting crystalline schists, and these may possibly be connected with the main intrusive system farther to the east. They carry small plates of muscovite mica, up to 3" across, and are similar in appearance and character to the pegmatite of Mica mountain, near Tête Jaune Cache.

Economic Possibilities of the Deposits.

Mica of good quality and in large-sized sheets has been shown to exist in the above-described section of British Columbia. It must be stated, however, that the remote location of almost all the claims so far taken up is a factor which renders mining an expensive and risky undertaking. Mica is not a mineral that habitually occurs in aggregations of large-sized crystals. The proportion of large crystals yielding sheets of 5"×8" and over, in the run-of-mine of any property, is small, not averaging over 5 per cent. A mica mine depends essentially on a uniform output of medium sized sheets, say 2"×3" grade, averaging a price of around 35 cents per pound; some mines run on a production of even smaller sizes than this. Large sheets are usually the exception rather than the rule, and there is no reason to suppose that the deposits in British Columbia are different in this respect to the majority of mica occurrences in other parts of the world. Thus, too much value should not be assigned to the samples of large-sized mica which this region yields; these sheets probably represent the best mineral which the dikes carry and are not a fair basis upon which to determine the value of the deposits. It should be remembered, however, that the high degree of erosion, which the upper portions of the mountains upon the dikes outcrop have been subjected to, has resulted, in some instances, in the accumulation of large quantities of pegmatite material upon the upper slopes. Thus, at some points, a considerable quantity of mica could possibly be secured with a minimum of expense, it being necessary merely to break up the boulders. Such methods would, of course, only hold for a limited time, and the pegmatite float would soon be exhausted. In addition, a considerable proportion of the mica recovered in this way would probably be impaired by weathering stains, and would be of inferior quality.

From experience of development work upon mica deposits in the east of Canada, and taking into consideration the necessary heavy expense entailed in exploiting such remote occurrences and the exceedingly short season during which work is possible, the writer is of the opinion that systematic mica mining in the Big Bend district is not practicable. Even the deposits in the Tête Jaune Cache district, which are relatively close to a railway, are hardly likely to prove capable of profitable exploitation.

III.

SALINE SPRINGS OF MANITOBA.

L. H. Cole.

The time between July 10 and September 1 was spent by the writer participating in three of the excursions of the International Geological Congress, and also attending the Congress meetings in Toronto. On September 1 he left the western excursion at Winnipegosis to continue his investigation of the occurrence of salt in the Province of Manitoba.

In order to make a thorough examination of the brine springs of the Province, the writer, during the month of September, gathered samples and the data required to prepare a final report for publication.

To facilitate easy reference to these springs—many of which are in unsurveyed territory—each locality has been indicated by a letter (see accompanying table), and its approximate location determined. The following notes briefly summarize the results of the investigation.

Salt in Manitoba.

It has been known for some time past, and in a few cases advantage has been taken, locally, of the fact that brine springs occur in many parts of northern Manitoba; but no extensive examination has been made of the localities in which they are found since Mr. J. B. Tyrrell made a brief reference to them in his report of the geology of northern Manitoba¹.

Winnipegosis District.

The springs included in this district lie along the west shore of Lake Winnipegosis and the shores of Dawson bay and the rivers tributary to it.

As all the brine spring localities are very similar in appearance, a general description will suffice. They may be described as barren areas, varying from a few acres to over a hundred acres in extent, surrounded by a few acres of meadow land, the whole being enclosed by timber, consisting of pine, spruce, and poplar. These barren areas, or salt flats as they are known locally, are very level, and are devoid of any vegetation, with the exception of occasional scattered patches of the red salt plant (*Salicornia herbacea*).

Here and there in the salt flat, brine springs bubble through the till, forming, in some cases, small truncated conical mounds of reddish scinter, in the centres of which lie clear pools of brine. In some of the springs bubbles of gas are constantly rising. The brine flowing from these pools spreads over the whole flats, and either evaporates, leaving a thin deposit of salt, or, if the flow is strong enough, forms a small stream of brine.

In some cases the brine is found in lakes or pools some 20 or 30 feet diameter, in which the surface is constantly moving, owing to the bubbling up of brine from below. These are surrounded by mud flats covered by a sod of coarse bunch grass. The ground in the vicinity of such springs is generally marshy.

The special data for each spring are given in the following tabulated form:

¹ Geol. Survey Canada. Annual Report, Vol. V, Pt. E.

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WINNIPEGOSIS DISTRICT—SALINE SPRINGS.

Springs Letter	Approximate Location west of Principal Meridian			General Location Description.	Approximate area (acres)		Flow of Brine Imp. Gals. per min.	Degree of Salinity	Remarks
	Section	Township	Range		Salt Flat	Meadow			
A.	33	24	43	To northwest of mouth of Bell river, Dawson bay, Lake Winnipegosis, Man.	30	7	17½	26°	About 15 springs are to be noticed in this area forming two streams which unite at end of meadow land and flow into Dawson bay.
B.	23	24	44	On west shore of Dawson bay, about 1 mile south of Salt Point, Lake Win- nipegosis, Man.	140	25	7½	26°	Numerous springs are to be found dotted over barren area. Only main flows could be measured. Probably 25% can be added to cover rest of flow.
C.	17	24	44	On south shore Dawson bay, 1 mile to east of mouth of Steeprock river, Lake Winnipegosis, Man.	16	2	45½	26°	Situated on sloping ground and brine flows directly into Dawson bay. Salt manufactured from this spring about 10 years ago for local use.
D.	17	24	44	On south shore Dawson bay, Lake Winnipegosis, Man. About 300 yards to east of Salt Spring area.	5	10	1½	26°	Probably a part of Spring C. Ground marshy and brine seep- ing out forming a small stream near lake edge where it was measured.
E.	11	25	44	On south bank of Steep- rock river, about 1 mile from mouth—Dawson bay Lake Winnipegosis, Man.	2	115	15½	12°	The greater part of this spring is boggy and covered with a thick growth of marsh grass through which the brine finds its way to the surface. Prob- ably about 30% can be added to amount of flow to cover loss by seepage.

E.	16	25	45	On north bank of Red Deer river, 1 mile from mouth, Dawson bay, Lake Winnipegosis, Man.	10	60	1	..	Flow estimated. Consisted of seepage from marshy flat. No definite spring could be seen.
F.	18	25	45	On north side of Red Deer river, about 2½ miles from mouth, Dawson bay, Lake Winnipegosis, Man.	..	20	3½	21°	Brine spring coming from low limestone ridge flowing two directions into Red Deer river.
G.	11	26	45	On south side of Red Deer river, about 4 miles from mouth, Dawson bay, Lake Winnipegosis, Man.	105	10	7½	24°	On flat ground. Brine flows two directions into Red Deer river.
H.	2	20	35	About 4 miles to southwest of Camperville, west shore of Lake Winnipegosis, Man.	12	..	14½	15°	This spring is situated in meadow land extending for several miles with occasional clumps of bushes and trees, locally called 'bluffs.'
I.	1	20	35	About 3½ miles to southwest of Camperville, on Pine creek, Lake Winnipegosis, Man.	1	..	14½	10°	Spring situated on steep bank of river and brine flows directly into river.
J.	21	18	32	On west shore of Lake Winnipegosis, Man., 12 miles north of town of Winnipegosis.	60	..	No flow measured	15°	Brine at this spring is found in wells or pits but no flow sufficient to be measured. Monkman's old spring from which salt was manufactured over 50 years ago for use of the Hudson Bay Co. Situated in meadow land similar to spring "H".

NOTE:—Salinity was measured in the field to gain an approximate idea as to the strength (NaCl) of the brine.

A salinometer was used on which 100° = a saturated solution of NaCl.

The amount of flow was measured by a right-angled V notch taking the measurement 2' from notch.

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Westbourne District.

In the district lying to the south of Lake Manitoba, between Portage la Prairie and the western boundary of the Province, a number of brine springs and wells, in which salt brine occurs, are known. A few of these were visited and sampled.

Tom Smith's Farm. Salt Well, K.

On this farm, situated one mile to the north of the town of Gladstone, a well has been sunk to the depth of 160 feet, and has been abandoned on account of salt water being encountered. The water from this well is quite saline to the taste, and the cattle on the farm will not use it at all.

James McBride's Farm. Salt Well, L.

This farm, on the east side of the road, $1\frac{1}{2}$ miles to the north of the town of Gladstone, has an abandoned well, the water in which is saline.

Westbourne Brine Spring, M. (Section 10, Township 10, Range 14, west of Principal Meridian).

About 7 miles west of Westbourne, on the north bank of the Whitemud river, a brine spring occurs. For several square miles to the north of this spring, the prairie is only sparsely covered with grass. Many patches are altogether bare, and the red salt plant and the characteristic surface deposit of alkali are found. Locally, this district is known as the Salt Flats. The spring consists of a pool of about 25 feet long by 10 feet wide, in which the brine is constantly bubbling up. A small channel, about 100 feet in length, carries the overflow—amounting to $36\frac{1}{4}$ gallons per minute—into the river.

At the water tank of the C.P.R., at Westbourne station, a well, sunk to a depth of 90 feet, was abandoned on account of alkaline water being encountered.

Government Well, Neepawa, Man.

On section 33, township 15, range 14, west of the Principal Meridian, the Manitoba government, in drilling a well for gas, encountered two flows of strong brine at depths of 1,225 feet and 1,455 feet. When it was visited on September 27, 1913, the depth of the well was 1,525 feet, and the brine from the second flow was still obtainable.

Winnipeg District.

A syndicate of Winnipeg men have drilled 7 wells in the district around the city of Winnipeg, and in 5 of them they encountered water of a more or less degree of salinity. The water from one of these wells, situated in Elmwood, Winnipeg, is being used by the Winnipeg Mineral Springs Sanitarium for mineral water baths, as a cure for numerous muscular diseases. The water, when charged with CO_2 and bottled, is being sold as a table mineral water.

The possibility of employing the brine from any of these springs commercially for the manufacture of salt cannot be definitely determined until all the analyses of the samples are made; but it is highly improbable that any of them will be of sufficient strength to warrant the erection of a plant on a large enough scale to produce salt to compete with the cheaply produced product of eastern Canada.

A couple of days were spent in the Ontario salt district, obtaining notes of any new development of the industry in this locality.

IV.

SUMMARY REPORT ON BITUMINOUS SANDS OF NORTHERN ALBERTA.

S. C. Ells.

Exploration of northern Alberta commenced with the advent of fur traders, in 1778. Subsequently, other explorers, either as private individuals, or in official capacities, have mapped out various portions of the area. Nevertheless, it may be said that, at the present time, but little information, official or otherwise, is available regarding the extent and actual value of the mineral resources of this area.

In spite of lack of detailed exploration and prospecting—discouraged in the past through absence of adequate transportation facilities—the occurrence of deposits of bituminous sands has been known for many years. It is now anticipated that the completion of the proposed Alberta and Great Waterways railway will, in the near future, remove the present handicap to the development of the mineral and other natural resources.

From time to time in the past, various opinions have been expressed regarding the probable economic value of the bituminous sands of the McMurray district.¹ In the absence of adequate accurate data, however, such expressions of opinion have been, of necessity, chiefly in the nature of surmises.

Owing to the large areal extent of the deposits, and to the limited time available, the work undertaken by the writer during the past field season can be considered as little more than a reconnaissance. It is thus possible that further and more detailed investigation may, to some extent, modify certain views here expressed. It is, however, hoped that the season's work may prove of some value, not only as a means for establishing certain conclusions, but also as a possible basis for further investigation.

At the present time, the commercial value of bituminous sands and sandstones, depends nearly altogether upon their use in a more or less modified form, in the construction and surfacing of certain classes of roads and pavements. In addition, however, to such applications, other possible uses for the extracted bitumen itself will at once suggest themselves. Among these, a few may be mentioned, as: floorings for many classes of buildings, such as mills, hospitals, schools and skating rinks; foundations that will absorb vibration and jar, as in electric power plants, or where heavy gravity or steam hammers are used; flooring, lining and damp courses for cellars, reservoirs, etc.; for fireproofing roofs; for insulation or preservation of various kinds of pipes; for heavy and waterproofing paints; and as a source of asphaltic oils for road preservation by sprinkling or "penetration" methods. These, and many other possible uses presuppose, in the case of the Alberta deposits, an efficient commercial extraction of bitumen from the siliceous mineral aggregate.

At various localities in the United States, during the past 20 years, the commercial extraction of bitumen from bituminous sands and sandstones has been attempted. In the carrying out of this work, a large financial outlay has been involved.

Generally speaking, commercial extraction in the past has been attempted by the use of solvents—principally carbon disulphide and lighter petroleum

¹ The area here, for convenience, referred to as the McMurray district, may be arbitrarily defined as lying between W. long. 110° and 113° and between N. lat. 56° 30' and 58°. Practically all exposures of bituminous sand in this area lie within a radius of 60 miles of McMurray. McMurray is situated some 230 miles to the north of the city of Edmonton.

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distillates—and by the use of hot water and steam. Of the first two solvents, carbon disulphide is more expensive and more volatile, while escaping fumes are a menace to the health of operators. In actual commercial practice, it appears that neither the use of naphtha nor of carbon disulphide has been successful.

The results when hot water and steam have been used have been more encouraging. A fairly rapid and comparatively inexpensive separation has been possible,¹ but in actual commercial practice the extraction has not been sufficiently complete. Summarizing all evidence at present available to the writer, it appears that the use of hot water will not give a commercial extraction of more than 60 per cent of the bitumen contained in average bituminous rock. In attempting to secure a higher percentage extraction, a disproportionate increase in cost will probably result. So far as the writer is aware, no commercial plants for the extraction of bitumen from bituminous sand-rock have been in operation in the United States for some years.

It is thus safe to say that, even apart from the actual merits of any of the processes that have been used, the extraction of bitumen from bituminous sand-rock has not met with commercial success. Nevertheless, in view of the various factors that must be taken into account in considering past attempts, it is difficult to say whether, under favourable conditions, commercial extraction may or may not be feasible. Meanwhile, those who may care to attempt extraction on a commercial scale and under conditions prevailing in northern Alberta will have available the results of many years' serious and often costly, experimentation, on which to base further effort.

The bituminous sands of Alberta, heretofore commonly referred to as "tar sands," outcrop at a large number of points along the Athabaska river and its tributaries for many miles to the north and south of McMurray.² Certain of these outcrops represent portions of the deposit that should prove to be commercially valuable, but it is also equally true that a very large portion of the area underlaid by bituminous sands, cannot be considered as of any economic value. In many instances it has been possible to definitely eliminate certain outcrops from further consideration, but, for reasons noted elsewhere, it is not, at the present time, an easy matter to definitely assert that certain other deposits will prove of commercial value. Opinions here expressed relative to outcrops, as well as estimated thickness of strata and overburden, are necessarily based solely on present surface indications, for, as stated elsewhere, only extensive stripping and other systematic exploration can render accurate data available.

Up to the present time no development work has been undertaken, nor has any effort been made to prove up any of the outcrops of bituminous sands in the McMurray district. Consequently in the present preliminary report, it would be unwise to venture a final opinion regarding the relative value represented by various outcrops. Mere measurements of imperfect vertical sections, arbitrarily taken at right angles to the face of the outcrop, unless supplemented by accompanying topographical maps, cannot convey much information. It is, however, believed that, from information already secured, an opinion may be formed of the relative value of the various separate areas referred to. Although

¹ After carefully going over the more or less incomplete records of a number of extraction companies, and having discussed the matter with men who have had wide experience in the operation of extraction plants, the writer believes that in California refined bitumen can be derived from bituminous sand, at a cost of \$12-\$13 per ton. In the same state petroleum residuum sells at \$7 per ton.

² Besides deposits of bituminous sand in the McMurray district, occurrences in the Province of Alberta have been recognized near Bonnie Glen (N.W. $\frac{1}{2}$ -Sec. 14-tp. 47-R. 27-W. of 4th Meridian), Nakamun (N.E. $\frac{1}{4}$ -Sec. 28-tp. 56-R. 2-W. of 5th Meridian), Legal (Sec. 28 and 32-tp. 57-R. 25-W. of 4th Meridian), Westlock (S.E. $\frac{1}{4}$ -Sec. 5-tp. 60-R. 26-W. of 4th Meridian), and elsewhere. At none of these localities has bituminous sand been found in commercial quantity, although it is but fair to say that as yet no systematic prospecting has been seriously undertaken. The deposits are, however, so situated that no great outlay would be required to finally determine their commercial value.

At present they are here referred to merely as easily accessible and typical examples of a type of deposit that appears to have a fairly wide distribution. In the opinion of the writer they are not "in place" and are therefore probably limited in extent. This conclusion has been arrived at after carefully examining such limited evidence as is at present available at the various localities mentioned.

the total area represented by actual outcrops has not been accurately determined, it is probably not less than 750 square miles. Extensions of the deposit under heavy cover, particularly toward the south, will greatly increase this estimated area.

At different points, wide variations occur in the quality of the material, the thickness and character of deposits, and in those topographical and geographical conditions which must, to a large extent, control possible future development. These features will be more fully referred to elsewhere, in discussing subdivisions of the main area.

It is not the writer's present intention to discuss the probable conditions that have resulted in the formation of the existing deposits, nor the origin of the bituminous content. Geologically, however, the bituminous sands represent the Dakota sandstones, and directly, but unconformably, overlie limestones of Devonian age. Originally in the form of soft sandstones and uncompacted sands, subsequent and more or less complete impregnation by heavy asphaltic hydrocarbons, has resulted in the present coherent material. Overlying the bituminous sands, and for the most part with a general dip to the south, are various soft Cretaceous sediments.

Assuming that the residual bitumen has been derived from an asphaltic petroleum, possibly originating in underlying Devonian strata¹, it seems probable that the inflow has been a horizontal one rather than an upwelling at many points over a large area. The very general absence of faulting appears to bear out this supposition. If such is the case, the enrichment of the deposit will vary from the main inlet or inlets, toward the outer margins of the basin, an assumption which appears to be borne out by actual conditions. It also seems probable that the folding of the Devonian strata was developed prior to the impregnation of the Dakota sands. Variation in the physical character and chemical composition of the contained bitumen, is, of course, to be expected, since the original petroleum would themselves, probably vary somewhat from point to point over so extensive an area.

General Character of Deposits.

A bituminous sand that will comply with standard paving specifications, should, generally speaking, primarily possess a certain grading of mineral aggregate and a certain percentage of a suitable bitumen. Within well defined limits, each of these constituents may be modified to conform with specified requirements.

Accurate and complete information regarding the various outcrops must be based on careful and systematic prospecting with proper appliances, and intelligent development of any deposit should be preceded by such preliminary work.

The lower limit of the bituminous sand is well defined by its contact with the Devonian limestone. There is not, however, any such well defined upper limit. Nevertheless, there is, in many instances, a more or less well defined line between what may be termed the high grade material of commercial value, and what must be classed as low grade material of little or no value. In the majority of well exposed sections, the richer material occurs in the lower part, shading off into the leaner grades in passing upward. In no instance was high grade sand found to directly underlie the superimposed shales, sandstones and drift.

It is also noticeable that the lower part of nearly all exposed sections consists of unstratified sands, and, prior to impregnation by the bitumen, these sands were apparently uncompacted. Consequently, the lower portion of the resulting

¹ In other parts of Canada and the United States, Devonian strata are known to be petroliferous and in the absence of evidence to the contrary it is quite possible that, in the present instance, the overlying Dakota sands have constituted reservoirs for petroleum derived from this source. One cannot but be impressed by the great period of time, and the extent of the original petroleum pools that have been required in the formation of the present deposits.



A

Grand rapids, Athabaska river.



B

Typical scenery on Chitina river



A

Typical quarry of bituminous sandrock, Asphalt, Ky.



B

Typical quarry of bituminous sandrock near Santa Cruz, Cal.

PLATE VI.



Quarry operated by A. Sattler, near Carpenteria, Cal., showing method of cutting down the asphalt in steps. The material is loaded into carts or railway cars, depending on where it is to be used.

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bituminous sands is generally of a more or less homogeneous character. In passing upward, however, narrow bands of sandstones and occasional quartzites are found interbedded with the originally uncompacted sands. These strata gradually increase until by their preponderance they entirely replace the bituminous sand. It will thus be seen that, in estimating the probable economic importance of any of the various outcrops, there are certain factors which demand careful consideration. Of these the following may be mentioned:

Thickness and character of overburden.—During the limited time available for such work, sections of a number of the more important outcrops were measured. In so doing, an attempt was made to determine thickness of bituminous sand of commercial grade; thickness of what may be referred to as low grade material, and of which probably the greater part must be classed as overburden, and, finally, the probable thickness of surface drift and other overburden to be removed by stripping. In many instances, earth slides, the encroachment of the timber line along the upper part of an exposure, and the presence of a more or less extensive talus pile along its foot, had partially obscured the outcrop. In such cases, the securing of accurate measurements would have necessitated extensive excavation work, and approximations were, therefore, made. For similar reasons it was found somewhat difficult to accurately indicate the length of many of the outcrops. Such data, even if available, would, however, frequently have little significance, since the occasional outcrops apparently merely represent small portions of one continuous deposit. Indeed it is quite possible that certain parts of the deposit, although at present partially or wholly obscured by timber or drift, may, on examination, prove to be more advantageously situated for development purposes than are many of the sections at present well exposed. For exposures naturally occur at bends of the stream where the current, impinging against the outer shore, has caused the formation of cut banks. So uniformly does this rule apply that, given an accurate map of any of the streams flowing through the area underlain by bituminous sands, it is possible to indicate very closely those points at which outcrops of bituminous sand will be found.

In the case of each deposit, it is, of course, assumed that any development must take the form of open cut mining or quarrying, thus presupposing a preliminary stripping of all overburden. In order to form some relative idea of the probable extent of such an undertaking, contour maps of eleven of the more promising areas were prepared. A study of these maps has shown that, viewed from the standpoint of overburden alone, a very considerable percentage of the total area underlain by bituminous sands may at once be eliminated from further consideration. In attempting to estimate the thickness and extent of overburden at any particular point, it is of value to remember that the upper horizon of the bituminous sand lies, for the most part, in an approximately horizontal position.

No discussion of geological sections along the Athabaska river is here required. Between Athabaska and the Cascade rapids, La Biche shales, Pelican sandstones and shales, Grand Rapids sandstones and Clearwater shales, are, at various points, well exposed; but northward and eastward from the Cascades rapids, the Clearwater series and surface drift appear to constitute the entire overburden above the bituminous sand. Thus, in undertaking stripping operations, the character of the material to be excavated should present no serious difficulty since shales and sandstones, with occasional thin bedded quartzites, represent the strata to be removed. The surface drift consists chiefly of boulder clays and sand. Only accurate topographical maps, supplemented by systematic boring, will furnish definite information regarding the quantity of overburden to be stripped. Meanwhile, possible stripping methods and the important problem presented by the disposal of waste material need not be discussed.

Obviously, however, other things being equal, areas situated at the junction of two streams present material advantages from the standpoint of removal of overburden.

As already noted, the lower part of the exposures usually consists of higher grade, and of more or less homogeneous, bituminous sand. But even here, certain variable features must be carefully considered.

Variation in mineral aggregate. Too much prominence cannot be attached to the importance of securing a product of uniform grade. Indeed, it would seem that this feature probably more than any other has, in the past, discouraged the development of many deposits of bituminous sand in the United States. In a body of siliceous sand of such wide areal extent as that under consideration, wide variations in the grading and purity of the mineral aggregate must be expected. Even within comparatively narrow limits, however, is this true in the McMurray district. In a number of cases where the grading of the mineral aggregate is not satisfactory, it appears probable, that, by combining the product from two or even three separate outcrops, a satisfactory grading will be obtained.

Variation in bituminous content. To some extent the degree of impregnation has depended on the grading of the sand. The medium grained and moderately compact deposit is usually the richest, whereas the finer grained aggregate has retarded a free penetration. Variation in the percentage of contained bitumen has already been referred to, and varies widely in all exposed sections examined. At some point in the majority of outcrops, however, a bed of bituminous sand of commercial dimensions, with a sufficiently uniform impregnation of bitumen, was found. Indeed it is probable that lack of uniformity, in the percentage of bitumen present in any one particular bed selected, will be one of the least serious difficulties to be considered.

Impure partings. Throughout a large number of the exposed sections examined, impure partings occur to a greater or less extent. In the majority of instances these partings, being impervious, act as sills, along which the bitumen from overlying sands concentrates. Seepages of semi-liquid bitumen, drawn to the surface by the action of the sun, are thus seen to follow roughly horizontal planes. In certain cases thin partings are so insignificant as to be practically negligible, but in other instances are so numerous, and of such dimensions, as to render the whole deposit worthless. The continuity or persistence of any band varies with its thickness. An interstratified band, 3 inches thick, may at times be traced hundreds of feet, while the length of a band, one quarter inch thick, rarely exceeds a few feet. Materials of which such partings are composed vary, but the more important may be briefly enumerated:

1. Clay.—This is usually a tough, sticky, impervious clay, showing little or no trace of bituminous impregnation. Although the thickness may vary from that of a knife blade to 12 inches, it rarely exceeds 3 inches.

2. Sandy clay.—The proportion in which the sand and clay are combined is, of course, variable. When the sand predominates, the content in bitumen may be as high as four per cent. When the clay predominates, the percentage of bitumen is practically nil.

3. Roughly stratified partings of lignitic particles are frequent, and at times attain a thickness of 6 inches. The fragments of lignite are usually not larger than a bean.

4. Roughly stratified partings of fine gravel.

5. Narrow sandy partings having a high percentage of fine micaceous particles. It will probably be possible to incorporate in paving mixes a certain percentage of material from these impure partings. To what extent this may be true can only be determined by laboratory tests and experimental mixes.



A

West side of Athabaska river at foot of Crooked rapid.



B

West side of Athabaska river below mouth of Pierre au Calumet.



A

East side of Athabaska river at Crooked rapid.



B

Typical outcrop, north side of Moose river, eighty miles from Winnipeg, showing effect of wet cliff drying out. This is too blurred to be of any real value.



A

West side of Athabaska river just above Crooked rapid.



B

East side of Athabaska river just below Mountain rapid.

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Having in view considerations such as the above, the desirability of securing accurate samples by the systematic boring of any selected area becomes obvious.

To some extent the percentage of contained bitumen, and the prevalence of impure partings, may be recognized in the appearance of an exposed section. Beds of high grade homogeneous bituminous sand are usually marked by a typical uneven cleavage roughly parallel to the face. Such a cleavage or flaking off is especially noticeable where heavy overburden has set up transverse pressure. Where the percentage of contained bitumen is low, the cleavage becomes more angular, and follows more and more the line of bedding planes.

When one considers the period of time during which the outcropping bituminous sand has been exposed to weathering agencies, and to alteration resulting from movement in the river banks, the difficulty of correctly interpreting surface indications is at once apparent. Only actual exploration of individual deposits will render available, data regarding the extent to which such alteration has taken place. Meanwhile analyses of samples taken at the surface and at a depth of 4 feet show practically identical results, and it is probable that alteration will generally not extend beyond such a depth. On steeply inclined cut banks lying above high water level, this absence of alteration is due, in part, to the flaking off of bituminous sand at frequent intervals. In other instances, however, where low lying deposits, less steeply inclined, are exposed to action of water, the zone of alteration will doubtless extend to greater depth.

Along the Athabaska river, outcrops of bituminous sands commence at a point near the Boiler rapid, and recur throughout a distance of 105 miles. On the various tributary streams outcroppings of bituminous sand may be traced for a total distance of some 70 miles.

Along both sides of these streams, it is probable that bituminous sands occur as a more or less continuous deposit. The actual outcrop is, however, frequently obscured immediately along the shores by timber, drift, and also as a result of heavy slides, and of changes that have, at various times, taken place in the stream channels.

As might be expected in a country covered by a heavy mantle of clay, and through which streams are deeply entrenched, slips in the banks constitute a notable feature. Individual slides at times bring down many hundreds of tons of clay and soil.

Slides of this type are especially prevalent, and their effects most marked where the retaining influence of forest growth has been removed by fire. This is particularly noticeable on the Christina river.¹ Along the lower part of this stream the forest growth has, to a considerable extent, prevented serious slips in the banks. A few miles from the mouth, however, where the country has been burned over, the greater frequency of slides is at once seen. The removal of the forest growth, as a preliminary to development work on deposits of bituminous sand, would thus necessarily intensify the effect of such slides; while subsequent stripping operations, undertaken on a large scale, would tend to still further destroy the equilibrium of the adjacent ground. The importance of this feature is further emphasized by the presence of numerous fissures in the clay and other surface deposits. These fissures, often of considerable length and extent, lie parallel with the top of the bank, and, in places, the strip of country thus affected, and rendered unstable, extends for upwards of 1,000 feet from the shore line. This fissured zone decreases in width as the overburden decreases in thickness.

Beyond the occurrences indicated on the accompanying map, other exposures of bituminous sand are reported at points, many miles to the east and west. These, however, require no consideration at the present time. If, among

¹ Formerly known as Pembina river.

the deposits already recognized in the McMurray district, none are commercially valuable, it is very doubtful if outlying areas of economic importance will be found north of Athabaska.

In considering possible development of any of these deposits, depth of overburden, freedom from impure partings, uniformity of material, and accessibility to transportation facilities, should be considered as chief controlling factors.

In descending the Athabaska river from Athabaska¹, the first outcrop of bituminous sand was observed just above the Boiler rapid, on the west side, although bituminous sand float was found some 4 miles farther south. At the former point the valley of the Athabaska is over 400 feet deep, the sides, for the most part, rising steeply from the water's edge. As such conditions implied a thickness of overburden altogether prohibitive, no actual measurements were taken between this point and the Cascade rapid. Throughout this distance of upwards of 18 miles, bituminous sands are probably more or less continuous along both sides of the valley, though the actual outcrop is frequently obscured. Such exposures as do occur are usually much banded, and much of the bituminous sand itself is of a low grade.

Between the foot of the Cascades and the forks at McMurray, a number of exposed sections were examined. Here, as elsewhere, owing to talus piles, clay slides and drift, difficulty was experienced in determining the lower limit of the bituminous sand, as well as the upper limit at which the material ceases to be of commercial grade. It appears, however, that in many of these sections beds of bituminous sand, of workable size, and of commercial grade, will be found. A very serious difficulty is presented by the heavy overburden, which will, at most points where sections are exposed, probably prohibit actual development. It should, however, be remembered that these exposures are usually found at the outer edge of river bends, where the stream has cut back into the higher ground, and has thus exposed high sections that necessarily show a heavy overburden. It is possible that a careful study of the less abrupt topography of the ground lying between such sections may, if accompanied by systematic borings, result in the discovery of workable deposits. Considering the forest growth and surface drift that will be met with, such work would be difficult and expensive.

Along the Athabaska river, north of McMurray, nineteen separate outcrops of bituminous sand were noted. Of these, thirteen of the more promising were examined in some detail.

Although all are outcrops of what is apparently one continuous deposit, there is, as elsewhere, considerable variation in the quality of material and in the mode of occurrence. Owing, in part, to the heavy overburden, and, in part, to the quality of the bituminous sand itself, quite 50 per cent of the thirteen outcrops examined may, for the present, be eliminated from further consideration.

Apart from exposures of bituminous sands along the Athabaska itself, frequent outcrops occur on a number of tributary streams. Of these, Horse creek, Hangingstone creek, Steepbank, Muskeg, Moose, McKay², and Christina rivers may be mentioned. Each of these has eroded a deep, notch-like valley, along the bottom of which winds a shallow, and often tortuous water course.

Outcrops of bituminous sand on these tributary streams may be grouped in two classes. A brief reference to the topography of Horse Creek valley will indicate the basis of classification. Less pronounced forms of these two types of deposit will be found along most of the other tributary streams of the McMurray district.

Horse creek flows through a deep, trough-like depression, older, apparently, than the relatively small water course that, at present, winds along its bottom.

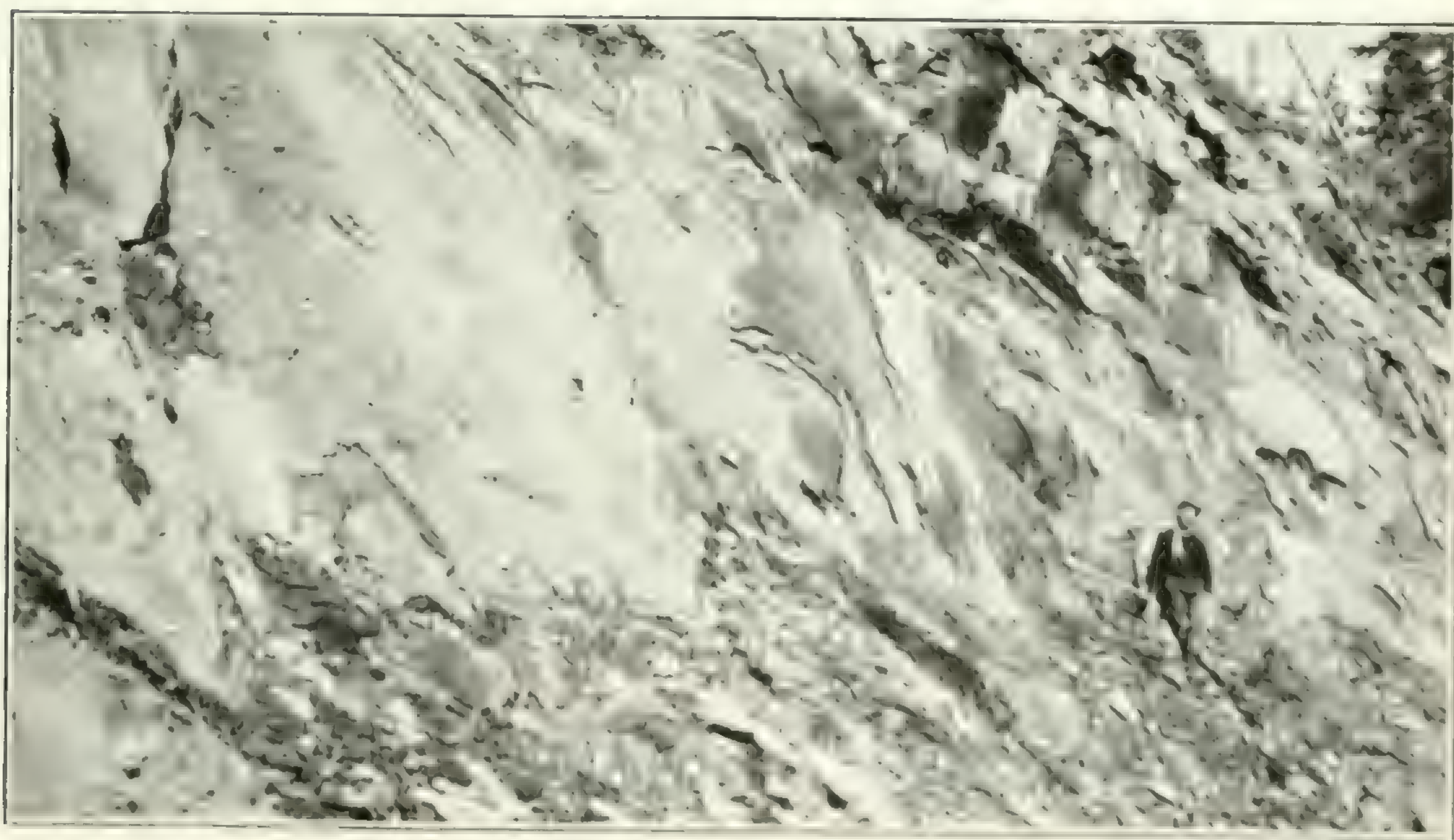
¹ Formerly known as Athabaska Landing.

² Formerly known as Red river.



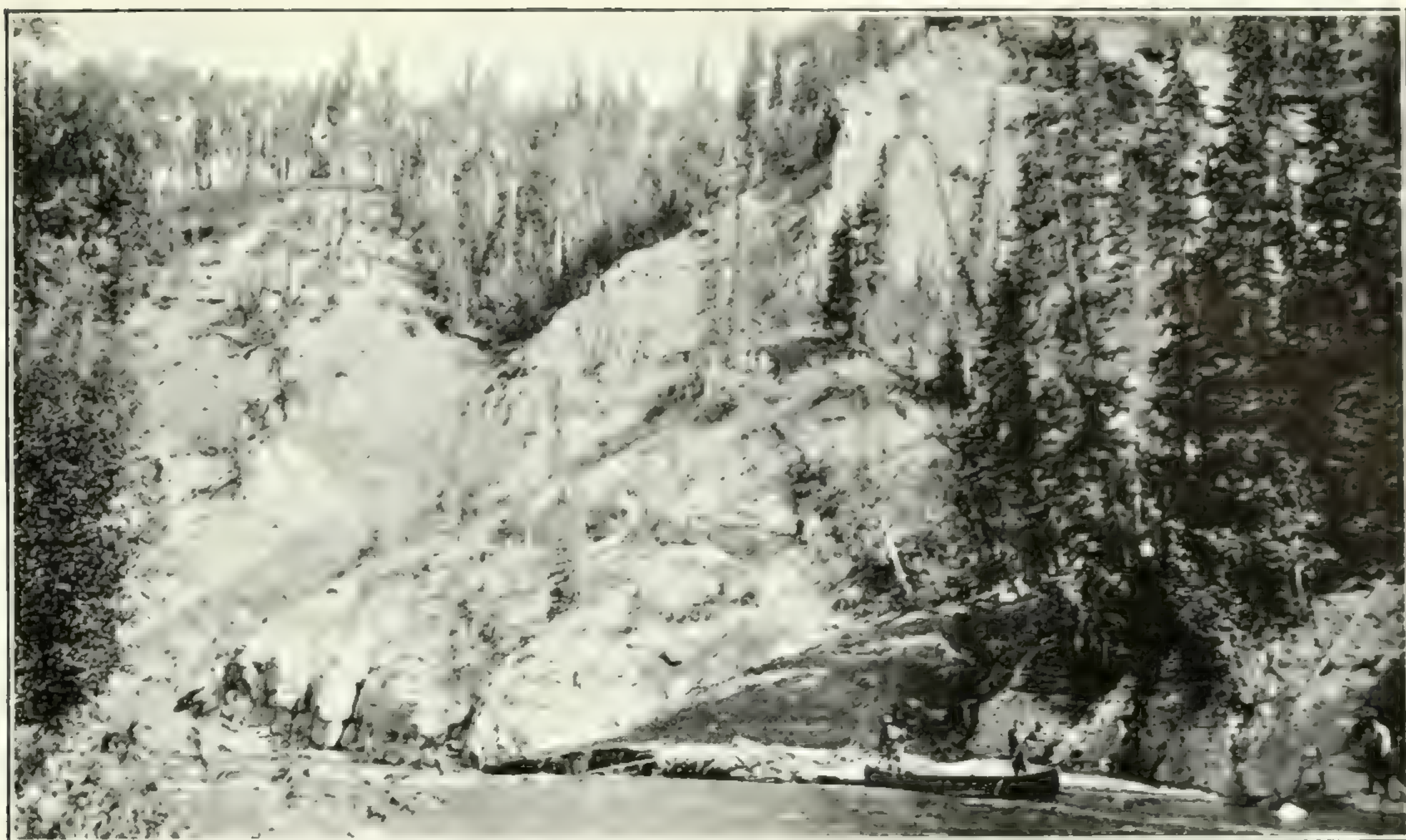
A

East side of Athabaska river, three miles below McMurray.



B

North side Steepbank creek, three and one third miles from mouth.



A

North side of Steepbank creek, two miles from mouth.



B

Typical example of clay shale



A

West side of Athabaska river, two miles north of Calumet river.



B

Athabaska river, east side, below Pierre au Calumet creek. Exposure No. 13, showing massive structure of bituminous sand and light overburden.

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The effective erosive power in this valley was, however, probably never equal to that of the Athabaska. Consequently, in the case of the Athabaska, we have to-day a river channel cut completely through the bituminous sands and well into the underlying Devonian limestone. The stream that eroded the Horse Creek valley did not, however, cut down to the base of the bituminous sand, and, as a consequence, the floor of the present valley is, for the most part, made up of bituminous sand. Into this floor, a diminishing flow of water has cut its way, and, in receding to its present insignificant channel, has left a series of well defined terraces of bituminous sand.

Horse creek flows through one of the older valleys of the McMurray district, and, except for the Clearwater river, its bottom lands are more extensive than those of any of the other tributary streams. Consequently, within the loops of its tortuous channel, areas of a few acres are sometimes found. Along the margins of certain of these bottom lands, erosion has exposed low faces of residual bituminous sand, overlaid by light gravel and other river wash. In other cases, the bituminous sand appears to have been eroded almost to present water level, and to have been replaced by sand and gravel.

Thus, on Horse creek—and to a lesser extent on certain other streams of this area—there are two types of deposits of bituminous sand:—

(a) Low lying deposits, outcropping to a height of 10 to 30 feet, immediately along the present stream channel. These exposures represent such small residual deposits of bituminous sand as still remain in the original valley bottom, and have a relatively light overburden.

(b) Exposures at points where the stream has impinged against the sides of the main valley. Such exposures, in general, resemble those already referred to along the Athabaska and exhibit a thick section of bituminous sand, and also a heavy overburden.

In the McMurray district there is thus a very large body of bituminous sand, the prospecting and developing of which will be confined to the stream valleys. The following constitutes a summary of the outcrops noted:—

Name of Stream.	Distance Through Which Exposures Occur.	Number of Outcrops.
Athabaska river.....	105	55
Horse creek.....	6	32
Hangingstone creek.....	6	11
Clearwater river.....	1	1
Pembina ".....	9	31
Steepbank ".....	10	35
Muskeg ".....	5	4
Calumet ".....	3	8
Tar ".....	6	7
Moose ".....	10	25
McKay ".....	16	38

Only after careful exploration, by means of adequate equipment, can the true value of any deposit be affirmed. Nevertheless, owing to heavy overburden and lack of uniformity in the quality of the bituminous sand, it is probable that quite 80 per cent of the exposures may be regarded as of no present commercial importance. Considerations affecting transportation will still further reduce the remaining number. Certain of the outcrops should, however, lend themselves to development on a commercial scale.

Bituminous sands have, for a number of years, been used in the construction of various classes of pavements in the United States, the principal sources of

supply at the present time being in Kentucky, Oklahoma, and California. The extent to which this material has been used appears to have been determined, to a considerable degree, by the fixing of freight charges. Apart from this consideration, political interests and the somewhat questionable methods peculiar to the asphalt industry itself should also be borne in mind.

From personal observation in various cities and towns in the United States, the writer believes that satisfactory pavements have been constructed, largely from bituminous sands. Certain of these pavements have been subjected to the comparatively light traffic of residential streets, while others have been tested under severe traffic conditions. On the other hand, many pavements laid with bituminous sand have proved unsatisfactory.

From a consideration of the successes and failures that have resulted from the use of bituminous sand rock, the writer would, in the strongest possible manner, emphasize one conclusion. It is, that the most careful study should be given to its chemical, but more especially to its physical character, as a preliminary step to actual attempts at paving. To handle our Canadian bituminous sand in a haphazard manner, either through failure to intelligently appreciate its true nature, or through lack of proper manipulation, will simply be to court failure and financial loss. The writer considers that the construction of one or more types of experimental pavement will prove to be the most satisfactory method of actually determining the real value that should attach to bituminous sand from the Alberta deposits.

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BUILDING AND ORNAMENTAL STONES OF QUEBEC.

Dr. W. A. Parks.

In accordance with instructions received from the Director of the Mines Branch I spent the three weeks from August 24, to September 14, in completing the investigations necessary for a report on the Building and Ornamental Stones of the Province of Quebec.

Three days were spent in the vicinity of Montreal, in order to bring up to date the information previously obtained there. The Villeray Quarry Company and O. Martineau et Fils are the only firms now producing building stone within the limits of the city, but new quarries in the "banc rouge" have been opened by the Lortie Quarry Co. and other operators on Masson street. The old quarries at Pointe Claire have been reopened for the production of crushed stone which is being used in connexion with the construction of the pumping station at Pointe St. Charles.

On leaving Montreal I spent a short time in visiting the abandoned quarries in the Trenton limestone at St. Cuthbert, St. Barthélemi, and other points along the north shore of the St. Lawrence. These quarries do not seem to promise a production except for local use although the quality of the stone is equal to that of the Montreal or St. Marc areas.

La Compagnie de Marbre du Canada has engaged in quarrying operations at Ste. Thècle in Champlain county. A mill has been erected and a small quarry about 50 feet square has been sunk to a limited depth on a band of crystalline limestone. The marble is normally of coarse grain and white, but, in places, it has been clouded with red and green by ferruginous matter from eruptive rocks. The possibilities of the quarry are reduced by the occurrence of lenticular masses and smaller blebs of this eruptive throughout the crystalline limestone. Operations had been suspended at the time of my visit.

At St. Joseph on the Chaudiere river a deposit of red marble is included between the slates of the region. The belt is of limited width, and is exposed at intervals for a distance of about 1,000 feet. The stone is of a bright red colour, and is cut by numerous white calcite stringers forming a very handsome marble. Test pits have been sunk at intervals, but no regular quarry has been opened. The limited width of the marble belt, and the presence of included slates, make it very doubtful if quarrying could be conducted on a commercial scale. The marble is very similar to that of deposits on the St. Francis river—below Richmond, and, in Orford mountain.

The large pit of the Asbestos Corporation of Canada, at Thetford Mines, was visited in order to determine if the excessive shattering observed at the surface of the serpentine belts showed any improvement at depth. The serpentine of the asbestos region is very dark and not of much promise as a decorative material. It was found that scarcely any improvement in the solidity of the formation occurs with increasing depth.

A few days were spent in an attempt to re-locate some of the reported occurrences of decorative serpentine, but it was found that without an excessive expenditure of time little could be learned beyond the information already published.

A second visit was made to the New Rockland slate quarry. The old workings in the big pit have been abandoned, and the company is now engaged in opening a new quarry on a belt of slate lying to the southeast of the deposit

originally worked. The marble quarry of the Dominion Marble Company, at South Stukely, was visited a second time also. The company has installed a new steel derrick, and has made other improvements since my former visit. With increasing depth the solidity of the formation is improving, and practically the whole of the material raised from the present floor of the quarry is capable of being sent to the mill. The company is also opening a new quarry in the yellow marble, and is obtaining mill blocks from the surface.

The eruptive masses of Brome and Shefford mountains have been quarried to a limited extent for building purposes. As this locality had not been visited previously, a short time was spent in examining the old quarries, none of which are now in operation. The stone is a coarse grained eruptive rock of a greyish-brown colour, which rapidly loses its brilliancy, and darkens under the action of the weather. I was impressed by the facility with which large blocks of stone could be quarried at different points on the northern side of Brome mountain.

The old quarries in red and in greenish slate, west of Granby, were visited. I am of the opinion that this region does not give much promise of production. On the other hand, the unworked slate belt at Garthby impressed me as worthy of serious prospecting.

Having completed the work which had been planned for the Eastern Townships, I proceeded to Ottawa, and by the instructions of the Director made an examination of certain quarry lands in the Potsdam sandstone of the township of Nepean, in Ontario.

From Ottawa a second visit was made to the quarry of the Pontiac Marble and Lime Company, at Portage du Fort. It was found that the company had made considerable advances in developing the quarry in the white crystalline limestone at this point. I understand that operations are being delayed pending the completion of the new Canadian Northern line to North Bay, which passes close to the property.

My last inspection was made on the east shore of Lake Timiskaming, where Routly and Summers of Haileybury have opened a small quarry in the belt of sandstone lying along the shore northward of Piché point. This stone is of light buff colour, and is coarse in grain, with a large amount of crystalline dolomite as the cementing material. The stone is soft when freshly quarried, but it hardens considerably on exposure; it has been used in the construction of the Presbyterian church in Haileybury. A somewhat similar, but much finer grained stone with a still higher dolomitic content, is quarried from time to time on the northeast side of Burnt island, in Lake Timiskaming, and is used in structural work in Haileybury and New Liskeard. This stone is a dolomite rather than a sandstone, and represents a higher level in the same series of beds, to which the deposits at Piché point belong.

I.

ORE DRESSING AND METALLURGICAL DIVISION.

G. C. Mackenzie,

Chief of Division.

The first five months of the year were devoted entirely to the installation of machinery and equipment for the new and enlarged metallurgical testing laboratory. Much difficulty was experienced in securing prompt delivery of some of the machinery, and as original plans and flowsheets required modifications to meet unforeseen conditions during the progress of installation, the laboratory was not completed as early as had been expected.

The assistant engineer, Mr. Fred Ransom, resigned his position in May, and this position remained vacant for two or three months.

In May, the writer organized a field party to prosecute further exploration of the magnetic iron sands of Natashkwan, Quebec. The party—consisting of G. C. Mackenzie; C. S. Parsons, assistant engineer; A. Fournier, transitman; and J. C. Bonham, sampler—left Ottawa on May 28, and arrived at Natashkwan, on June 6.

After making a permanent camp, and laying out the field work, the writer handed over control of the party to Mr. Parsons and returned to Ottawa. Mr. Parsons' report on the field work will be found under section III, p. 90.

During the summer months, installation of machinery for the metallurgical laboratory was continued. Mr. W. B. Timm was appointed assistant engineer, and placed in charge of the metallurgical laboratory during the absence of the writer from headquarters. Mr. Timm's report will be found under section II, p. 66.

In July, the writer acted as secretary for excursion A-2 of the Geological Congress, in Central Ontario. Official duties prevented the acceptance of position as guide on two other Ontario excursions.

In August, a short trip was made to Sault Ste. Marie, Ontario, for purposes of consultation with the city authorities regarding a Government test of the Michaelson crushing and concentrating machinery.

The Michaelson Company, having asked the city of Sault Ste. Marie for certain concessions to enable them to manufacture their machinery in that city, agreed to submit sample machines for testing under approved conditions. The test, however, was not carried through, as the Michaelson Company did not have, at that time, any machines completed to their satisfaction.

In October, the writer was instructed to proceed to Nelson, B.C., to take charge of the experiments in electric smelting of zinc ores for the Mines Branch, under the direction of Mr. W. R. Ingalls, Consulting Engineer to the Dominion Government.

II.

THE WORK OF THE ORE DRESSING AND METALLURGICAL
DIVISION FOR 1913.

W. B. Timm.

Although the installation of machinery in the new testing laboratories was not completed, it was found necessary to commence operations with such portions of the plant as were in shape. During the last four months of the year, tests were conducted on the ores tabulated below:

LIST OF ORES TESTED.

No. of Test.	Ore.	Locality.	Shipper.	Weight of Shipment.	
				Tons.	Pounds.
15	Molybdenum ..	Lot 16, Con. XI, township of Brougham, county of Renfrew, Ontario.	C. G. Ross, Esq., Customs Dept., Ottawa.		200
16	Molybdenum ..	Lot 8, Con. XI, township of Brougham, county of Renfrew, Ontario.	Renfrew Molybdenum Mines, Mount St. Patrick, Ontario.		350
17	Copper.....	Four miles N.W. of Mileage 40, Algoma Central Ry.	Superior Copper Co., Sault Ste. Marie, Ontario.		200
18	Iron.....	Lot 22, Con. IV, township of Levant, county of Lanark, Ont.	T. B. Caldwell, Esq., Lanark, Ontario.		280
19	Zinc.....	Hudson Bay Mine, Deer Creek, West Kootenay district, B.C.	P. F. Horton, Esq., Salmo, B.C.		200
20	Iron.....	Groundhog, Ont., Algoma district.	John A. Dresser, Esq., Sault Ste. Marie, Ontario.	15	

TEST NO. 1.

Molybdenum Ore.

A small shipment of 200 pounds of the ore was received from Mr. C. G. Ross. It was taken from the surface workings on lot 16, con. XI, township of Brougham, Renfrew county, Ontario.

The ore consists of molybdenite associated with pyrrhotite and pyrite in a pyroxenite and actinolite gangue. A small amount of mica, quartz, and calcite are also present. Between the laminae of the molybdenite are found embedded small crystals of pyrrhotite and pyrite.

The crude ore was crushed in the jaw crusher set at $\frac{3}{4}$ " opening. After a rough hand-cobbing, it was passed through rolls set at $\frac{1}{4}$ " opening. The prod-

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uct from this crushing was screened on a 3-mesh Sturtevant screen. The over-size was passed through the rolls, and screened on the 3-mesh screen. This operation was repeated three times, resulting in a high grade molybdenite concentrate remaining on the screen.

The physical character of the ore permits the crushing of the gangue material to pass through the screens, while a large percentage of the molybdenite particles are flattened out, and remain on the screen.

The material through 3-mesh was screened on a 4-mesh Sturtevant screen, and the above operation repeated. These successive screening and rolling operations were conducted on the material on the 6, 8, 10, 12, and 20-mesh screens.

The following high grade concentrate was obtained:

Hand cobbled.....	1 pound, 9 ounces.
Caught on 3-mesh screen.....	0 " 11 "
" 4 "	0 " 8 "
" 6 "	0 " 13 "
" 8 "	0 " 7½ "
" 10 "	0 " 4 "
" 12 "	0 " 5½ "
" 20 "	0 " 11 "

A total of.....5 pounds, 5 ounces.

The tailing resulting from the above concentration was sized on 30, 40, 50, 60, 80, and 100-mesh screens, and the sized products were passed through the Huff electrostatic separator, to obtain a separation of the molybdenite remaining in the tailing from the gangue by this process.

A good separation was not effected. The other sulphides were drawn over by the electrode to a considerable extent. In order to clean these concentrates, rolling and screening was found necessary.

Huff Electrostatic Separation of Molybdenite Tailing.

Sized product—20+30; Weight 53½ pounds.

Voltage on electrode, 20,000; Passes, 12.

The concentrate obtained was rolled and screened on 30, 40 and 50 mesh screens.

Concentrate caught on 30-mesh screen, 11 ounces.

"	"	" 40-mesh	"	3	"
"	"	" 50-mesh	"	2	"

The tailing through 50-mesh was screened and added to the sized products+60+80+100 and—100.

Sized product—30+40; Weight 49 pounds.

Voltage, 15,000; Passes, 6.

The concentrate obtained was rolled and screened on a 40-mesh screen; 7 ounces of high grade concentrate were caught on the screen. The tailing through 40-mesh was screened and added to the sized products+50+60+80+100 and—100. From the final screening on 40-mesh some concentrate was obtained on 50-mesh which was added to the Huff concentrate—40+50.

Sized product—40+50; Weight 28 pounds.

Voltage 15,000; Passes, 6.

The concentrate obtained was rolled and screened on a 50-mesh screen; 6 ounces of high grade concentrate were caught on the screen. The tailing through 50-mesh was screened and added to the sized products+60+80+100 and—100. From the final screening on 50-mesh, some concentrate was obtained on 60-mesh which was added to the Huff concentrate—50+60.

Sized product—50+60; Weight, 19½ pounds.
Voltage, 20,000; Passes, 6.
The concentrate obtained was rolled and screened on a 60-mesh screen; 3 ounces of high grade concentrate were caught on the screen. The tailing through 60-mesh was screened and added to the sized products+80+100 and—100.
Sized product—60+80; Weight, 21 pounds.
Voltage, 20,000; Passes, 8.
The concentrate obtained was rolled and screened on 80-mesh screen; 4 ounces of high grade concentrate were caught on the screen.
The tailing through 80-mesh was screened and added to the sized products+100 and—100.
Sized product—80+100; Weight 19 pounds.
Voltage, 20,000; Passes 6.
The concentrate obtained was rolled and screened on a 100-mesh screen; 2 ounces of high grade concentrate were caught on the screen.
The tailing through 100-mesh was added to the product —100.
Sized product—100; Weight, 56 pounds.
Voltage 20,000; Passes, 8.
The concentrate obtained was rolled and screened on 120-mesh screen; 1 ounce of high grade concentrate was caught on the screen.
The tailing from the Huff electrostatic separator was weighed and samples taken of the various sizes for analysis.

Tailing	Weight		Analysis	
	Pounds.	Ounces.	% MoS ₂	% Mo
—20 + 30	28	8	1.18	0.71
—30 + 40	36	8	2.32	1.39
—40 + 50	23	0	1.40	0.84
—50 + 60	15	0	2.32	1.39
—60 + 80	15	8	1.93	1.16
—80 +100	15	0	1.93	1.16
—100	54	0	2.13	1.28
Totals and Averages.	187	8	1.93	1.15

The high grade concentrate obtained from the above tests, was sized, weighed, and samples taken of the various sizes for analysis.

Concentrate	Weight		Analysis	
	Pounds.	Ounces.	% MoS ₂	% Mo
On 2-mesh	1	1½	94.55	56.72
" 4 "	1	11	90.18	54.10
" 8 "	1	5	92.19	55.29
" 16 "	0	13	84.16	50.49
" 30 "	1	4½	74.51	44.70
" 50 "	0	12	62.14	36.68
" 80 "	0	5	52.94	31.76
" 100 "	0	2	65.51	39.30
Through 100 "	0	1½	72.36	43.41
Totals and Averages.....	7	7½	82.73	49.63

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From the above table we derive the following:—

Material	Weight.		Analysis.		Contents MoS ₂ pounds.	Contents Mo pounds.	Percentage crude contents.
	lbs.	ozs.	%MoS ₂	%Mo			
Tailing.....	187	8	1.93	1.15	3.62	2.17	36.93
Concentrate.....	7	7½	82.73	49.63	6.18	3.71	63.06
Crude.....	194	15½	5.02	3.01	9.80	5.88	99.99

Crude ore treated,
Concentrate obtained,
Analysis of concentrate,
Recovery,
Loss in tailing,
Analysis of crude ore.

195 pounds.
7 pounds 7½ ounces.
82.73% MoS₂, or 49.63% Mo.
63.06%
36.93%
5.02% MoS₂, or 3.01% Mo.

TEST No. 2.

Molybdenum Ore.

Two shipments of ore: one of 100 pounds and the other of 250 pounds, were received from the Renfrew Molybdenum Mines, Mount St. Patrick, Ont. The ore was obtained from the mine workings, situated on lot 8, con. XI, township of Brougham, county of Renfrew, in the Province of Ontario.

The ore is similar to that described in Test No. 1. The molybdenite was found to be associated with pyrrhotite and pyrite, in a pyroxenite and actinolite gangue. Small amounts of quartz, calcite, and mica were also visible in the gangue material.

The crude ore was crushed in a jaw crusher set at ¾" opening, screened on a 2-mesh Sturtevant screen, the oversize crushed in rolls set at ⅜" opening. The following screening products were obtained:

2-mesh	7 pounds, 12 ounces.
— 2+ 4 "	108 " 12 "
— 4+ 8 "	44 " 9 "
— 8+16 "	32 " 10 "
— 16+30 "	30 " 8 "
— 30 "	24 " 0 "
A total of 248 " 3 "	

The sized products were rolled and screened on their respective mesh five consecutive times, the rolls being adjusted for each crushing. The material passing through the screens was sized and added to the above sized products. From this operation a high grade concentrate of 9 pounds 3½ ounces was obtained.

Sized product.	Weight.		Mesh screened on.	Weight of concentrate.	
	Pounds.	Ounces.		Pounds.	Ounces.
- 2 + 2-mesh	7	12	4	0	5½
- 2 + 4 "	108	12	4	1	4
- 4 + 8 "	108	6	8	2	0
- 8 +16 "	111	10	16	2	6
-16 +30 "	128	8	30	2	8
-30 "	19	8	60	0	12
Total concentrate, 9 lbs., 3½ ozs.					

Only the richer portion of the material through 30-mesh representing 19 pounds, 8 ounces, was rolled and screened on 60-mesh. The screenings through 30-mesh were kept separate and samples taken for analysis.

Screening.	Weight.		Analysis.
First.....	45 lbs.	4 ozs.	1.16% Mo.
Second,.....	63 "	8 "	0.40% "
Third,.....	56 "	8 "	0.58% "
Fourth,.....	26 "	8 "	0.53% "
Fifth,.....	21 "	0 "	0.92% "
Through 60 mesh,.....	17 "	0 "	5.61% "

Analysis of the concentrate showed it to contain 85% MoS₂. A recovery of 77% of the molybdenite values was obtained. The loss in tailing was 23% of the molybdenite values. An analysis of the crude ore was not made, but from the analysis of the concentrate and tailing it was found to contain 4.3% MoS₂.

Concentration by Preliminary Crushing and Screening Followed by Magnetic and Electrostatic Separation.

A portion of the ore was taken, crushed in the jaw crusher, passed over a 10-mesh screen, the oversize crushed in rolls and screened until what remained on the 10-mesh screen was a high grade molybdenite concentrate, representing 30% of the molybdenite values in the crude ore.

The material through 10-mesh was sized on 20 and 40-mesh. It was found that the greater proportion of the molybdenite values was in the coarser size, the fine sized product through 40-mesh containing such small amounts that it might not be advisable to treat it further.

The sized products -10+20; -20+40, and -40 were fed dry to the Ullrich magnetic separator. The pyrrhotite, representing 60% by weight, was separated from the molybdenite, pyrite, pyroxenite and other non-magnetic gangue material. An analysis made of the magnetic product showed it to contain iron 50%, sulphur 32%, insoluble 17%, with traces of molybdenite.

The non-magnetic product from the magnetic separator was given an oxidizing roast and passed through the magnetic separator. The pyrites made slightly magnetic was separated from the molybdenite and gangue.

The non-magnetic product from the second separation was experimented with on the Huff electrostatic separator, but it was found that the physical properties of the contained minerals were so changed that a good separation could not be made.

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First. The concentration made by successive rolling and screening would necessitate the installation of such an extensive plant of rolls and screening devices, that would exempt it from being a commercial process.

Second. A separation could be attained on the Huff electrostatic separator of the molybdenite, pyrrhotite and pyrite from the other gangue material, but a good separation could not be made of the molybdenite from the pyrrhotite and pyrite by this process.

Third. The pyrrhotite could be separated from the molybdenite, pyrite and gangue by magnetic separation on the Ullrich separator.

Fourth. After separating the pyrrhotite from the molybdenite, pyrite and gangue, a separation of the molybdenite and pyrite from the gangue could probably be attained by the Huff electrostatic separator.

Fifth. A separation of the molybdenite from the pyrite could be made by giving the material an oxidizing roast and passing it through a magnetic separator. A high grade molybdenite concentrate should be obtained which would probably require screening to free it from dust and other fine particles adhering to it in the operation.

Sixth. After the separation of the pyrrhotite and pyrite from the molybdenite and gangue, the latter product should be adaptable to flotation. It would be free from the sulphides which have a tendency to float with the molybdenite particles.

TEST No. 3.

Copper Ore.

A 200-pound shipment of ore was received from the Superior Copper Co., Sault Ste. Marie, Ont. The ore consists of chalcopyrite; associated with it is a dark coloured material, probably altered diorite, finely disseminated through a quartz gangue.

The ore was crushed in the jaw crusher set at $\frac{3}{4}$ " opening, passed over a 3-mesh screen, the oversize being returned to the crusher set at $\frac{1}{2}$ " opening and passed over the 3-mesh screen. The oversize from the latter screening was crushed in rolls set at $\frac{1}{4}$ " opening, and passed over the 3-mesh screen.

The crushed ore was sized on 4, 6 and 8-mesh screens, but it was found by experimenting with these sizes on the laboratory jig that the sulphides were not freed from the gangue sufficiently to obtain a clean concentrate. They were recrushed in rolls until the total product passed through an 8-mesh Sturtevant screen.

The crushed ore through 8-mesh was closely sized. The sized products up to 30-mesh were jigged on the laboratory type single compartment Richard's pulsating jig. The sized products above 30 mesh were concentrated on the laboratory type Wilfley table.

The concentration obtained and the results of this test are contained in the following table:—

Sized Products.	Head.			Concentrate.			Tailing.		
	Weight.		Percent- age of crude.	Anal. %Cu.	Contents Pounds.	Weight. lbs. ozs.	Anal. %Cu.	Contents Pounds.	Weight. lbs. ozs.
	lbs.	ozs.							
- 8 + 10	54	0	30.39	2.40	1.2960	2 5	19.06	.4405	50 14
- 10 + 12	23	1	12.98	2.82	.6520	1 5	20.72	.2725	21 2
- 12 + 14	15	8	8.72	4.36	.6755	2 3	14.72	.3238	13 5
- 14 + 16	8	8	4.78	3.38	.2870	0 14	19.90	.1752	6 12
- 16 + 18	7	8	4.22	4.02	.3017	0 14	20.28	.1785	6 8
- 18 + 20	4	12	2.67	3.70	.1759	0 9	17.80	.1000	4 0
- 20 + 22	4	4	2.39	4.30	.1827	0 11	18.20	.1274	3 10
- 22 + 24	4	0	2.25	4.40	.1760	0 11	19.06	.1334	3 5
- 24 + 30	10	0	5.63	4.62	.4620	2 8	17.06	.4265	7 10
- 30 + 35	4	6	2.46	4.56	.1995	0 15	18.56	.1740	3 0
- 35 + 40	2	10	1.48	4.37	.1147	0 9	17.42	.0981	1 14
- 40 + 45	2	0	1.13	4.90	.0980	0 8	16.22	.0811	1 7
- 45 + 50	4	2	2.32	4.70	.1940	0 14	18.90	.1655	3 0
- 50 + 60	2	7	1.37	5.20	.1267	0 8	19.94	.0997	1 10
- 60 + 70	2	6	1.34	4.84	.1150	0 8	18.32	.0916	1 10
- 70 + 90	1	5	0.74	5.64	.0742	0 5	15.60	.0492	0 12
- 90 + 100	0	10	0.35	4.90	.0306	0 3	12.26	.0230	0 5
- 100 + 110	1	3	0.67	4.76	.0565	0 5	15.63	.0492	0 12
- 110 + 120	2	3	1.23	4.96	.1085	0 9	15.36	.0861	1 5

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-120 + 130	2	3	1.23	5.46	.1195	0	10	14.84	.0932	78.2	1	3	1.24	.0147
-130 + 150	1	0	0.56	5.85	.0585	0	5	12.00	.0378	64.6	0	7	1.46	.0064
-150 + 200	1	3	0.67	4.66	.0542	0	6	11.00	.0413	76.2	0	9	1.42	.0080
-200	18	8	10.41	4.40	.8140	5	6	9.86	.5305	65.2	3	13	1.16	.0042
Totals and Averages.....	177	11	99.99	3.59	6.3727	23	15	15.87	3.7981	59.6	138	13	1.45	2.0178
Totals and Averages above 20-mesh.....	2.9846	15	13	14.59	2.3076	77.0	36	4	1.07	.3877

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Weight of crude ore sized.....	177 pounds, 11 ounces.
Analysis of crude ore.....	3.59% Cu.
Weight of concentrate obtained.....	23 pounds, 15 ounces, or 13.5% of crude ore.
Analysis of concentrate.....	15.87% Cu.
Recovery in concentrate.....	59.6%
Weight of tailing.....	138 pounds, 13 ounces, or 78.1% of crude ore
Analysis of tailing.....	1.45% Cu.
Loss in tailing.....	40.4%

Omitting the coarser sizes up to 20-mesh, on which a poor concentration was obtained, due to the sulphide particles not being freed from the gangue, and the tailings of which would be recrushed in actual practice, the finer sizes above 20 mesh show the following concentration:—

Analysis of concentrate.....	14.59% Cu.
Recovery in concentrate.....	77.0 %
Analysis of tailing.....	1.07% Cu.
Loss in tailing.....	23.0 %

In concentrating the finer sizes of the sized products on the Wilfley table, a concentrate, tailing, and a float concentrate were obtained. The float or slime concentrate was caught in a compartment box and added to the heavy concentrate. This could be provided for in practice along similar lines, and the results obtained would correspond to the latter figures.

Dry Concentration by Electrostatic Separation.

The sized products, -24+30, representing the coarser sizes and -200 representing the finer sizes, were experimented with, to obtain a concentration by the use of the Huff electrostatic separator. The following results were obtained:—

Sized Product.	Huff Concentrate.	Huff Tailing.	Voltage on Electrode.	No. of Passes.
-24 +30	15.42% Cu.	0.65% Cu.	20,000	8
-200	9.26% Cu.	1.99% Cu.	18,000	12

The results from the finer size could possibly be improved on by more careful adjustment of the machine. The results are so satisfactory that further experiments will be conducted on this ore.

TEST NO. 4.

Iron Ore.

A small shipment of 280 pounds was received from Mr. T. B. Caldwell, Lanark, Ont. The ore was taken from the stock pile, and was supposed to be an average sample. The deposit is located on lot 22, con. IV, township of Lavant, county of Lanark, Ontario, near Flower station, on the Kingston and Pembroke railway.

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The ore consists of a fine grained magnetite, massive, through which is disseminated fine pyrites, hornblende and calcite gangue.

The ore was crushed to pass through a 100-mesh Sturtevant screen. A head sample was obtained by passing it through a Jones riffled sampler. The remaining material was emptied into a push feeder, and fed automatically to the Ullrich four-pole magnetic separator. Wet separation was employed. The current strength on the machine was 4.5 amperes. Six products were obtained; four of concentrate (one from each ring of the machine), and two of tailing. The various products were dried, and samples taken for analysis. From the results obtained, the table given below was compiled.

Head Sample Analysis.

Insoluble	15.35%
Iron.....	58.6 %
Phosphorus.....	.048%
Sulphur.....	.248%

Product.	Weight.		Per- cent- age of crude ore.	Analysis.				Sample No.	Analysis.				Averaged Analysis.				Combined weight.		Per- cent- age of crude ore.	Calculated Average Analysis.			
	lbs.	ozs.		% In- soluble.	% Fe.	% P.	% S.		% In- soluble.	% Fe.	% P.	% S.	% In- soluble.	% Fe.	% P.	% S.	lbs.	ozs.		% In- soluble.	% Fe.	% P.	% S.
Concentrate from No. 1 Ring.	86	14	33.05	8.84	64.8	.023	.206	A-2	8.84	64.8	.023	.206	8.75	64.7	.023	.211							
				9.20	64.6	.026	.206	B-2	9.20	64.6	.026	.206											
				8.20	64.6	.021	.220	C-2	8.20	64.6	.021	.220											
Concentrate from No. 2 Ring.	81	2	30.87	8.60	65.0	.018	.212	A-3	8.60	65.0	.018	.212	8.67	64.7	.019	.212							
				9.20	64.5	.017	.204	B-3	9.20	64.5	.017	.204											
				8.20	64.6	.021	.220	C-3	8.20	64.6	.021	.220					235	3	89.48	9.34	64.2	.022	.219
Concentrate from No. 3 Ring.	60	0	22.83	8.64	65.0	.022	.226	A-4	8.64	65.0	.022	.226	8.76	64.9	.022	.220							
				9.00	64.8	.022	.220	B-4	9.00	64.8	.022	.220											
				29.44	47.3	.037	.360	C-4	29.44	47.3	.037	.360											
Concentrate from No. 4 Ring.	7	3	2.73	27.50	48.5	.044	.372	A-5	27.50	48.5	.044	.372	28.91	48.1	.042	.369							
				29.80	48.6	.046	.376	B-5	29.80	48.6	.046	.376											
				72.00	9.9	.186	1.05	C-5	72.00	9.9	.186	1.05											
Tailing from Rings.	12	14	4.90	72.30	9.1	.152	.96	A-1	72.30	9.1	.152	.96	71.43	9.7	.175	1.00							
				70.00	10.0	.187	1.00	B-1	70.00	10.0	.187	1.00					27	10	10.51	73.39	9.2	.183	1.05
				75.24	8.9	.187	1.00	C-1	75.24	8.9	.187	1.00											
Tailing.	14	12	5.61	75.00	8.4	.196	1.13	A-6	75.00	8.4	.196	1.13	75.11	8.7	.190	1.10							
				75.10	8.9	.187	1.17	B-6	75.10	8.9	.187	1.17											
								C-6															
Totals and Averages..	262	13	99.99	262	13	99.99	16.07	58.45	.039	.306

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The units of crude required per unit of concentrate:—

$$\frac{64.2 - 9.2}{58.45 - 9.2} = 1.16$$

The percentage of iron in the crude saved in the concentrate:—

$$\frac{100 \times 64.2}{58.45 \times 1.16} = 94.69\%$$

Units of tailing made per unit of concentrate, 0.16.

The percentage of iron in the crude lost in the tailing:—

$$\frac{100 \times 9.2 \times 0.16}{58.45 \times 1.16} = 2.17\%$$

Tons of concentrate made per ton of crude = 0.895.

Calculations of iron saved from actual weights and analyses:—

$$\frac{235.2 \times 64.2 \times 100}{262.8 \times 58.45} = 98.3\% \text{ of the iron in the crude saved in the concentrate.}$$

$$\frac{27.6 \times 9.2 \times 100}{262.8 \times 58.45} = 1.7\% \text{ of the iron in the crude lost in the tailing.}$$

From the above table, it will be noticed that the concentrate from ring No. 4 shows an analysis of insoluble, 28.91%; Fe, 48.1%; P, .042%; S, .369%. By raising this ring, a concentrate could be obtained similar to that from the first three rings. Four important adjustments of the separator on which the results of the test largely depend are the amount of feed water used; the rate of feed; the distance of the rings from the feed and the strength of current on the fields. There was not sufficient ore to make accurate adjustments and obtain the best results. A run of this ore using the Grondal wet magnetic separator would give a comparative test of the efficiency of the two machines.

TEST NO. 5.

Zinc Ore.

A shipment of 200 pounds of the ore was received from Mr. P. F. Horton, of the Hudson Bay mine, Salmo, B.C. The ore was taken from the mine workings 166 feet below the surface.

The ore is a zinc silicate; associated with it are small amounts of, possibly lead silicate and considerable limonite. Analysis of the ore shows it to contain silver and gold in small quantities. The minerals are very closely disseminated, making it very difficult to obtain a separation.

Experiments were conducted to effect a wet concentration by the use of hydraulic classifiers, jigs, and Wilfley tables. A small amount of the fine limonite was washed away, raising the zinc content five per cent, and decreasing the iron content by a similar amount. With this one exception, no concentration was obtainable, due to the closely disseminated character of the mineral constituents of the ore and to no marked difference in their specific gravity.

Experiments were also conducted to effect a dry separation on the Huff electrostatic separator. The results obtained were not satisfactory.

Electrostatic Separation after Flash Roasting.

Seventy pounds of the ore were taken, and crushed in the laboratory jaw crusher, set at $\frac{1}{2}$ " opening. The material from the crusher was passed over a 10-mesh Sturtevant screen, the oversize fed to rolls, set at $\frac{1}{4}$ " opening, and passed over

Iron Product.

Sized Products.	Weight.		Percentage of roasted ore.	Analysis.		Contents	
	lbs.	ozs.		% Zn.	% Fe.	lbs. Zn.	lbs. Fe.
—10+16	1	0	11.11	32.18	16.8	0.322	0.168
—16+20	0	12	20.00	29.78	19.0	0.233	0.143
—20+30	1	15	44.93	32.18	16.2	0.623	0.314
—30+50	1	4	32.26	25.96	22.7	0.325	0.284
—50	1	12	16.47	24.96	22.3	0.437	0.390
Totals and Averages....	6	11	21.19	29.01	19.4	1.940	1.299

Average analysis of iron product :	Zinc.....	29.01%
	Iron.....	19.4 %
Zinc values of crude ore in iron product.....		16.6%

Magnetic Separation after Roasting in Reducing Atmosphere.

A portion of the ore through 10-mesh was given a reducing roast, and sized on a Sturtevant 40-mesh screen. The sized products were treated separately on the Ullrich magnetic separator.

Head Analysis before Roasting.

Zn., 34.16%; Fe., 10.7%; Ag., 1.2 ozs.; Insoluble, 24.56%.

Head.

Sized Products.	Weight.		Percentage ore.	Analysis.		Contents.	
	lbs.	ozs.		% Zn.	% Fe.	lbs. Zn.	lbs. Fe.
+ 40	11	8	66·67	39·84	9·4	4·582	1·081
— 40	5	12	33·33	32·55	15·2	1·872	0·874
Totals and Averages....	17	4	100·00	37·42	11·3	6·454	1·955

Zinc Product.

Sized Products.	Weight.		Percentage of roasted ore.	Analysis.		Contents.	
	lbs.	ozs.		% Zn.	% Fe.	lbs. Zn.	lbs. Fe.
+ 40	8	0	69.57	42.45	5.4	3.396	0.432
- 40	3	0	52.18	36.20	7.0	1.086	0.210
Totals and Averages....	11	0	63.77	40.75	5.8	4.482	0.642

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Eighth. A portion of the original shipment remains, on which a test will be made along the following lines, namely, the ore will be calcined to convert the iron into the ferric state, crushed to pass through 10-mesh, violently washed to free the iron from the zinc particles, and the entire product run through the wet magnetic separator.

The following flow sheet shows the method of procedure of the tests conducted on the Huff electrostatic separator and the dry magnetic separator, the results of which are given above.

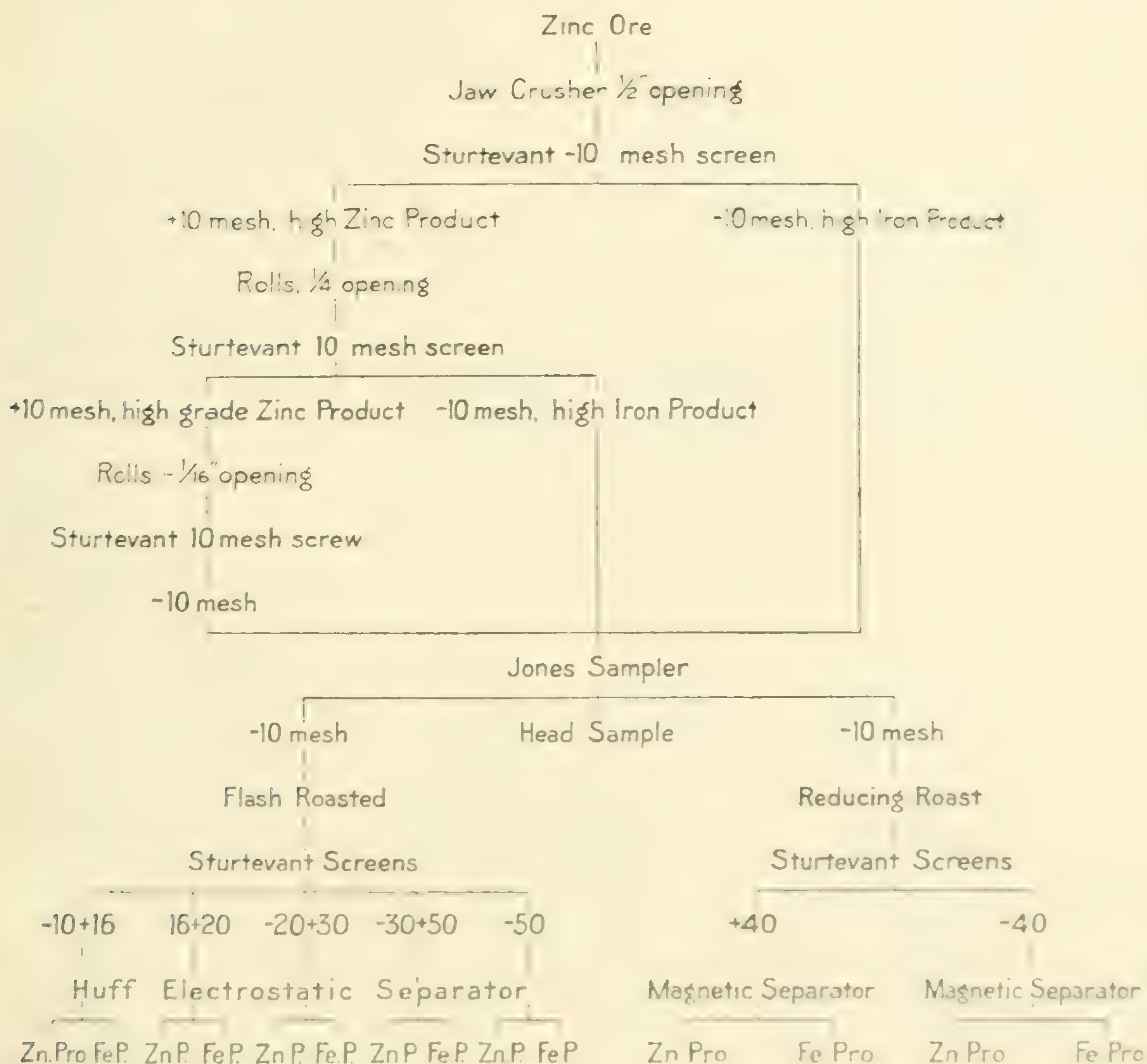


Fig. 4. Flow sheet, Test No. 5

TEST NO. 6.

Iron Ore.

A 15 ton shipment of the ore was received from Mr. John A. Dresser, Sault Ste. Marie, Ont. The ore was taken from the surface of the deposit, situated at Groundhog, Ontario. It consists of bands of magnetite, hematite and jasper. A run of the ore was made over the Gröndal dry separator, after sizing on Ferraris screens.

A portion of the ore was taken, crushed in jaw breaker set at 1" opening, run through rolls set at 1/2" opening, through a Vezin sampler, and over the Ferraris screen. The oversize, +1", was recrushed in rolls, and run over the screen until it all passed through the 1" screen.

The following sized products were obtained:—

Sized Product.	Weight. Pounds.	Percentage by Weight.	Analysis. % Fe.
— 1" + 3/4"	570	19.8	35.05
— 3/4" + 1/2"	772	26.8	33.75
— 1/2" + 1/4"	579	20.1	34.40
— 1/4" + 1/8"	404	14.0	35.00
— 1/8" + 1/16"	272	9.4	34.28
— 1/16"	284	9.9	34.10
Totals.....	2881	100.0	

Analysis of head sample from Vezin sampler: 35.10% Fe.

The sized products were run over the Gröndal dry separator, with varying strengths of current on the drum. The middlings from the coarser sizes, -1" + 3/4"; -3/4" + 1/2", and -1/2" + 1/4", were recrushed, sized on 1/8" and 1/16" screens, and passed over the separator for reconcentration. The middlings from the recrushed middlings were added to the middlings from -1/4" + 1/8" and -1/8" + 1/16" of the first screening, and concentrated on a Richard's pulsating jig. The tailing from

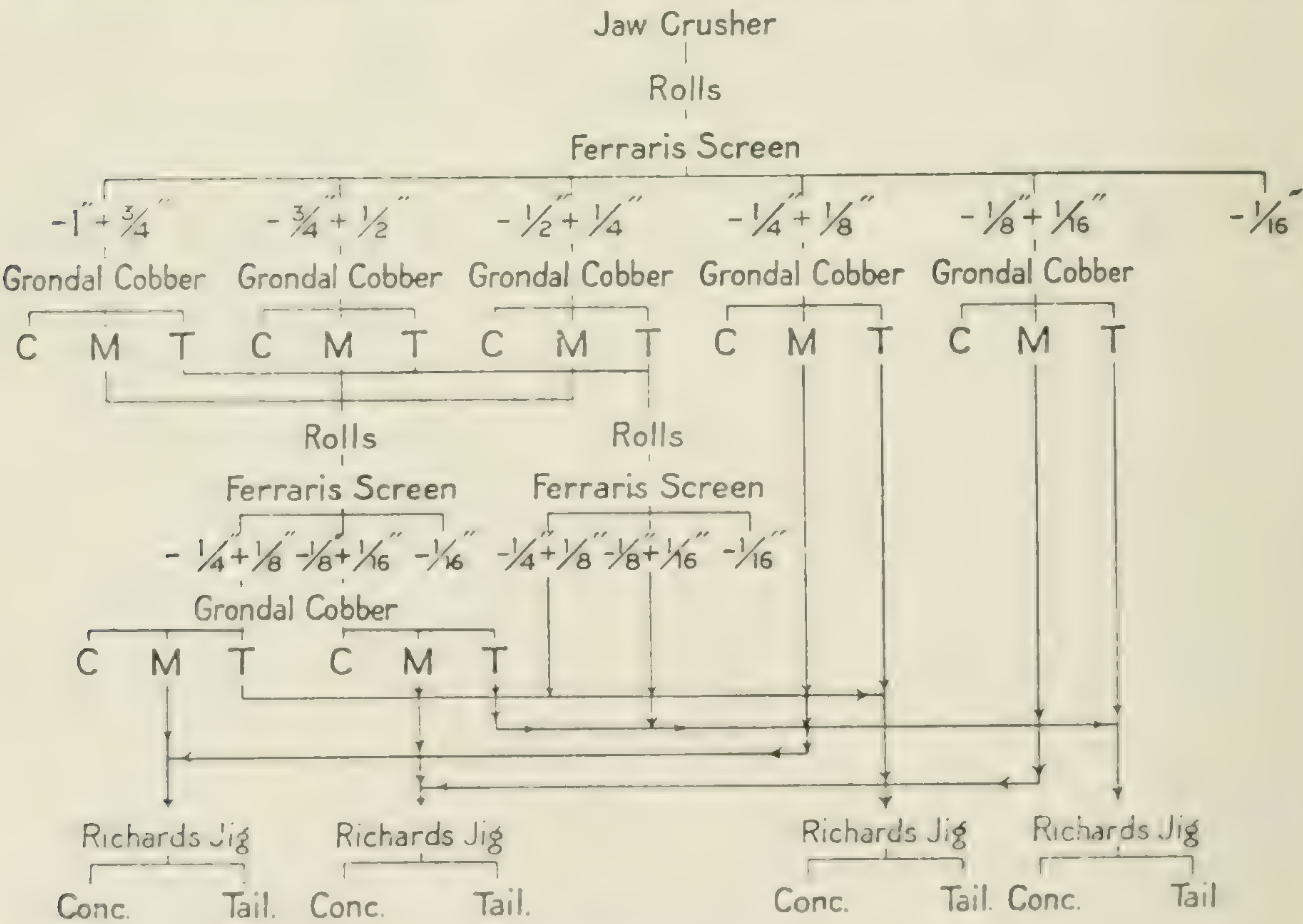


Fig. 5. Flow sheet, Test No. 6.

the coarser sizes was recrushed, screened, and added to the tailing of the finer sizes of the first screening and concentrated on the Richard's pulsating jig.

The above flow sheet shows the method of procedure in conducting this test.

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The results obtained from the dry magnetic separation are tabulated as follows:—

Tables Nos. 1, 2, 3, and 4 give the results obtained by varying the strength of current on the separator drum; table No. 5, the concentration of the re-crushed middling; table No. 6, the jig concentration of the middling, and table No. 7, the jig concentration of the tailing.

Table No. 1. Dry Magnetic Concentration of Sized Products.

Sized Products.	Current Strength.		Head.		Concentrate.					Middling.					Tailing.				
	Belt Amps.	Drum Amps.	Weight Pounds.	Analysis % Fe.	Contents Pounds.	Weight Pounds.	Percent-age by weight.	Analysis % Fe.	Contents Pounds.	Percent-age by weight.	Weight Pounds.	Analysis % Fe.	Contents Pounds.	Percent-age Fe. of head	Weight Pounds.	Percent-age by weight.	Analysis % Fe.	Contents Pounds.	Percent-age Fe. of head
-1" + 1"	6	30	432	35.05	151.48	93	21.5	48.90	45.48	30.0	288	32.70	94.18	62.2	51	11.8	20.90	10.66	7.04
-1" + 1"	6	30	692	33.75	233.45	160	23.1	48.70	77.92	33.4	445	31.15	138.62	59.4	87	12.6	21.50	18.70	8.01
-1" + 1"	6	30	552	34.40	189.88	190	34.4	48.00	91.20	48.0	307	27.10	83.20	43.9	55	10.0	19.50	10.73	5.65
-1" + 1/8"	6	30	348	35.00	121.80	145	41.7	49.64	71.98	59.1	163	26.86	43.78	35.9	40	11.5	20.04	8.02	6.58
-1/8" + 1/16"	6	30	221	34.28	75.76	94	42.5	50.80	47.75	63.0	91	27.00	24.57	32.4	36	16.3	18.50	6.66	8.79
Totals and averages ..	..	..	2245	34.40	772.37	682	30.4	49.02	334.33	43.3	1294	29.70	384.35	49.8	269	12.0	20.36	54.77	7.09

Table No. 2. Dry Magnetic Concentration of Sized Products.

Sized Products.	Current Strength.		Head.		Concentrate.					Middling.					Tailing.					
	Belt Amps.	Drum Amps.	Weight Pounds	Analysis % Fe.	Contents Pounds.	Weight Pounds.	Percent-age by weight.	Analysis % Fe.	Contents Pounds.	Percent-age Recovery.	Weight Pounds.	Percent-age by weight.	Analysis % Fe.	Contents Pounds.	Percent-age Fe. of head.	Weight Pounds.	Percent-age by weight.	Analysis % Fe.	Contents Pounds.	Percent-age Fe. of head.
-1" + 1"	6	30	432	35.05	151.48	93	21.5	48.90	45.48	30.0	288	66.7	32.70	94.18	62.2	51.	11.8	20.90	10.66	7.04
-1" + 1"	6	30	692	33.75	233.45	160	23.1	48.70	77.92	33.4	445	64.3	31.15	138.62	59.4	87	12.6	21.50	18.70	8.01
-1" + 1"	6	30	552	34.40	189.88	190	34.4	48.00	91.20	48.0	307	55.6	27.10	83.20	43.9	55	10.0	19.50	10.73	5.65
-1" + 1/8"	6	25	370	35.00	129.50	121	32.7	51.40	62.19	48.0	206	55.7	28.35	58.40	45.2	43	11.6	20.35	8.75	6.75
-1/8" + 1/16"	6	25	233	34.28	79.87	87	37.4	52.20	45.41	56.9	104	44.6	28.60	29.74	37.2	42	18.0	19.00	7.98	10.00
Totals and averages	2279	34.41	784.18	651	28.6	49.50	322.20	41.1	1350	59.2	29.93	404.14	51.5	278	12.2	20.44	56.82	7.24

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From the above tables it will be noticed that Table No. 1 shows the better recovery of the iron contents, and, by endeavouring to increase the grade of the concentrate, this recovery is decreased to such an extent, as is shown in Tables Nos. 2, 3, and 4, that the figures of Table No. 1 were used as a basis on which the actual recovery was calculated.

Heads from Table No. 1.

Weight.....	2,245 pounds.
Analysis.....	34.40% Fe.
Contents.....	772.37 pounds metallic iron.

Concentrates from Table No. 1.

Weight.....	682 pounds, or 30.4% of crude ore.
Analysis.....	49.02% Fe.
Contents.....	334.33 pounds metallic iron.
Recovery.....	43.3% of the iron content in crude ore.

From Table No. 1, the middlings concentrated on the separator should be the sum of the combined weights of the middlings from the three coarser sizes, less the fines from recrushing.

Middlings from coarser sizes = 1040 pounds.

Proportion of middlings concentrated to fine discarded is as 642: 206, or 75.7%.

75.7% of 1040 pounds = 787 pounds.

From Table No. 5, 11.5% of this weight was concentrate.

11.5% of 787 pounds = 81 pounds.

The concentrates obtained from the treatment of the middlings should be:—

Weight.....	81 pounds, or 3.6% of the crude ore.
Analysis.....	51.8% Fe.
Contents.....	41.96 pounds metallic iron.
Recovery.....	5.4% of the iron content in crude ore.

From Table No. 5: 57.1% of the middlings run over the separator for re-concentration were middlings.

57.1% of 787 pounds = 449 pounds.

There were 254 pounds of middling from the finer sizes, making a total of 703 pounds to be jigged.

From table No. 6, we find that a concentration of 25% of the original jig was obtained.

25% of 703 pounds = 176 pounds.

The concentrates obtained from the treatment of the middling in the Richard's jig should be:—

Weight.....	176 pounds, or 7.8% of the crude ore.
Analysis.....	51.7% Fe.
Contents.....	90.99 pounds metallic iron.
Recovery.....	11.8% of the iron content in crude ore.

From Table No. 7 it is shown that a treatment of the tailing is not practical.

By dry concentration of the sized products on the magnetic separator, re-concentrating the recrushed middlings from the coarser sizes, and jigging the sized middlings from the separator, the following concentration is obtained:

Concentrate Weight.	Percentage of crude ore.	Analysis % Fe.	Contents Pounds Fe.	Per cent Recovery.
682	30.4	49.02	334.33	43.3
81	3.6	51.80	41.96	5.4
176	7.8	51.70	90.99	11.8
939	41.8	49.8	467.28	60.5

Concentrate obtained = 939 pounds..... = 41.8% of the crude ore.....
Analysis of concentrate..... = 49.8% Fe.
Recovery of iron content..... = 60.5%.
Omitting the retreatment of the middlings on the Gröndal dry separator, but by adding these products to the two finer sizes of middlings and jiggging this product, the results obtained would be approximately as follows:—
784 pounds + 254 pounds = 1,041 pounds to be jigged.
From Table No. 6, we find that a concentration of 25% of the original jig head was obtained. This would probably be increased in treating the higher grade middling.
25% of 1,041 pounds..... = 260 pounds.
Weight of concentrate..... = 260 pounds, or 11.6% of the crude ore.
Analysis of concentrate..... = 51.74% Fe.
Contents of concentrate..... = 134.52 pounds metallic iron.
Recovery of iron content in crude ore.... = 17.3%.
By dry concentration of the sized products on the magnetic separator, re-crushing the middlings from the coarser sizes, and jigging the sized middlings from the separator, the following concentration should be obtained:—

Concentrate. Weight.	Percentage of crude ore.	Analysis % Fe.	Contents Pounds Fe.	Per cent. Recovery.
682	30.4	49.02	334.33	43.3
260	11.6	51.74	134.52	17.3
942	42.0	49.8	468.85	60.7

Concentrate.....942 pounds..... = 42.0% of crude ore treated.
Analyses of concentrate..... = 49.8% Fe.
Recovery of iron content..... = 60.7%.
Considering the concentration products of the fines—1/16" as being too fine for the blast furnace, the percentage of concentration and recovery would be lower than the figures given above.
To the sized products from table No. 1 must be added the proportion of fines, 9.9% of the crude ore crushed.

Products.	Weight.	Analysis.	Contents.
+ 1/16"	2,245	34.40	772.37
– 1/16"	219	34.10	74.68
Totals.....	2,464	34.38	847.05

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By dry concentration of the sized products on the magnetic separator, reconcentrating the recrushed middlings from the coarser sizes, and jigging the sized middlings from the separator, the following concentration is obtained:—

Concentrate obtained. .939 pounds. = 38.11% of the crude ore.

Analysis of concentrate. = 49.87% Fe.

Contents—metallic iron. = 467.28 pounds.

Recovery of iron content. = 55.16%.

By dry concentration of the sized products on the magnetic separator, recrushing the middlings from the coarser sizes, and jigging the sized middlings from the separator, the following concentration should be obtained:—

Concentrate.942 pounds. = 38.23% of the crude ore.

Analysis of concentrate. = 49.8% Fe.

Contents—metallic iron. = 468.85 pounds.

Recovery of iron content. = 55.23%.

A jig test of the sized products is being conducted on a portion of the shipment. A magnetic wet separation test will be made, and a magnetic dry separation test, followed by jigging, a flow sheet of which is given on page 82.

III.

INVESTIGATION OF THE MAGNETIC IRON SANDS
AT NATASHKWAN, QUE.*C. S. Parsons.*

During the summer of 1912, what appeared to be a large and rich deposit of black magnetic sand was discovered. Time did not permit the examining of this deposit, so it was thought advisable to continue the investigation during the summer of 1913. About four months' work was accomplished on this new deposit, which lies $4\frac{1}{2}$ miles east along the coast from the mouth of the Natashkwan river. An old river channel is plainly marked at this point, and the deposit forms the east bank of its bed.

The whole deposit was sampled, with the use of the Empire drill and outfit. This drill is operated by hand power, and consists, briefly, of a 4" steel pipe casing, made in 5 feet sections. The end of the pipe is fitted with a cutting shoe, and is slowly rotated and sunk by the combined weight of a platform, and of the men who stand on it. Water is supplied to the interior of the pipe, and the core which accumulates is pumped out with a churn drill pump by the men who stand on the platform.

An area of 340 acres was blocked off into squares of 500 feet to a side, and five holes were drilled on each square; one in the centre, and one at each corner. Levels were run to ascertain the contour of the ground for the correct calculation of the tonnage. A log of each bore hole was kept, and a sample of every 5 feet taken. This sample was analysed in the field, by means of a hand magnet. The entire core from each drill hole was bagged, numbered, and collected for shipment to Ottawa, where a large scale test on the concentration of the sand will be made.

By referring to the accompanying map, and to the tabulated analysis of each bore hole, it will be observed that the distribution of the black sand is very irregular; and by examining the logs of a few typical holes which are shown, it may be seen that the black sand lies in layers or bands of variable thickness. The layers are very irregular in thickness and in lateral extent. In a distance of 50 feet, laterally, they may grade from two or more feet in thickness, down to a few inches, or disappear entirely. No black sand was discovered below a certain level. In this deposit it was found to be, approximately, between 8 to 10 feet above high water; while in the deposit drilled during the preceding summer, it was at a point somewhere between high and low water. The average depth at which the bore holes lost the black sand was 25 feet; although in a few holes which were drilled on high ground, black sand was found 40 feet from the surface.

The black sand is concentrated from the ordinary red granite sand on the slope of the beach by the wave action. The waves rush up the beach, and in their return action, drag the lighter grains of sand down the slope, leaving behind the heavy grains of black sand, in a more concentrated state. By this action, layers of pure black sand are formed on the beach, anywhere from one inch to 2 feet thick. The ebb tide leaves this layer of sand exposed to the wind and sun. As the sand dries, it is carried inland by the wind, and again subjected to a concentrating action during the formation of sand dunes.

The deposit drilled this season bears evidence that it has risen about 8 feet since it was formed, for coarse, water-worn sand may be observed 8 feet above the present high water mark. The banks of the deposit are now, however, being washed away, and the sand seems to be carried westward towards the present river mouth by a strong current setting along the shore. This current is met

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by the current from the river, and the sand is thrown back on the beach on the east side of the river, and concentrated there. The river has worked its way continuously westward from the old river bed mentioned before, and has gradually built up behind the first, a second deposit of concentrated black sand similar to that which forms the east bank of the old river channel. This newly formed deposit at the present mouth of the river—which was drilled during the previous summer (1912), seems to have been formed under the same conditions as the older deposit. The one is practically the duplicate of the other. The trend of the sand dunes is the same in each deposit. The ground near the present mouth of the river is very poor, and will not average over three per cent of black sand; but becomes much richer as the eastern end of the deposit is approached. This is also true of the older deposit, situated east of the old river bed.

It is probable that the constant shifting of the river channel westward accounts for the fact that the deposit at Natashkwan is much larger than any of the deposits found at the mouth of the other rivers entering the gulf.

Regarding the likelihood of other deposits existing in this locality, this much may be said: that there is a possibility of other deposits being found, occurring as raised beaches between the Natashkwan and the Kegashka river, which is 17 miles east. The country lying between these two rivers is low and flat, and made up of a loose sand containing about one per cent in black magnetic sand. Over the surface of this plain, which is partly wooded and partly peat bogs, are a few chain-like systems of sand hills, which rise abruptly from the plain. Numbers of these pinnacle-shaped hills, which are often 90 feet high, were drilled with a sand auger, but only a trace of black sand was discovered. A few miles inland the Laurentian granite is found, and this, without doubt, formed the old shore line. As raised beaches which are over 200 feet above sea level are known to occur farther down the gulf, and the country about Natashkwan harbour, 4 miles west of the river mouth, also shows evidence of having been recently submerged, it is reasonable to expect that similar beaches of black sand may exist along the border of the granite between the two rivers.

Following is a list of the bore holes drilled during the summer of 1913, also four logs of different holes, illustrative of black sand distribution, and rate of drilling.

A full and complete report on these sands, containing the tonnage estimates and the results of the experiments carried on in connexion with their concentration, is being prepared, and will be published at a later date.

Percentages of Magnetic Concentrate obtained in the Field with a Hand Magnet.

Bore hole. Number.	Depth of hole. Feet.	Concentrate. Average % per foot.	Remarks.
C.D. 10-11	35	5.00	First 10' through peat not calculated.
C. 10	30	4.56	" " " " " "
C. 11	30	2.48	" " " " " "
C.D. 11-12	25	3.12	" " " " " "
C. 12	25	1.96	" " " " " "
C.D. 12-13	25	4.53	" 8 " " " "
C. 13	25	1.45	" 10 " " " "
C.D. 13-14	25	2.48	" 5 " " " "
C. 14	25	3.39	" 10 " " " "
C.D. 14-15	25	2.28	" 5 " " " "
C. 15	25	2.04	" 10 " " " "
C.D. 15-16	25	2.66	
C. 16	25	2.88	" 5 " " " "
C.D. 16-17	25	3.13	" 5 " " " "
D. 17	25	2.17	" 10 " " " "
D. 16	25	1.66	" 10 " " " "
D.E. 15-16	25	13.61	
D. 15	25	2.21	
D. E. 14-15	20	12.11	
E. 15	25	10.90	
E. 14	25	9.87	
E. 13	25	15.66	
E.F. 13-14	20	10.30	
D.E. 13-14	25	11.51	
D. 14	25	3.51	
D. 13	20	3.46	
D.E. 12-13	25	9.72	
D. 12	30	11.78	
D.E. 11-12	25	6.04	

Log.

Bore hole No. D.E. 15-16. In bush. June 28, 1913.
Started to drill hole 2.15 p.m.

Feet.		Sand.	Black sand.	Black sand. %
0	Hard pan (cemented sand) } Very good black sand	100 grams.	22.89	22.84
5	Very good black sand	100 "	27.02	27.02
10	Not so very good			
13	Fair black sand } Not so good as at 13 ft.	100 "	13.02	13.02
15				
18	Very little black sand } Fair black sand	100 "	2.53	2.53
19				
20	Much better black sand } Not so good	100 "	1.23	1.23
22				
25	Red sand }			
Average per foot				13.61 B.S.

Remarks—
Pulled casing of drill 8.40 a.m.
3½ bags of sand.
Moved drill to D 15 and set up 9.15 a.m.

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Log.

Bore hole No. D. 11

In bush.

July 5, 1913.

Started to drill hole 2, p.m.

Feet.		Sand.	Black sand.	Black sand. %
0	Good black sand }	100	17.17	17.17
5	Good black sand }			
10	Very good black sand	100	14.28	14.28
15	Extra good black sand	100	15.20	15.20
	Extra good black sand }	100	22.67	22.67
	Extra good black sand }			
19	Not so good			
20	Extra good black sand }			
	“ “ “ “ }	100	28.17	28.17
	“ “ “ “ }			
25				
27	Getting poorer			
28	Good black sand }	100	13.92	13.92
	“ “ “ “ }			
30	“ “ “ “ }			
	Fair black sand			
	Not much black sand }	100	5.66	5.66
35	Not much black sand }			
	Not much black sand }			
	“ “ “ “ }	100	0.93	0.93
	Coarse red sand }			
40	“ “ “ “ }			
		Average black sand, per foot...		14.75

Remarks—

Finished hole 3.40 p.m. Pulled casing and moved to D.E. 10-11 and set up 4.35 p.m.

5 $\frac{1}{4}$ bags of sand.

Log.

Bore hole No. E.F. 11-12.

Bush.

July 17, 1913.

Started to drill at 2.10 p.m.

Feet.		Raw sand.	Black sand.	Black sand.
0	Fair black sand Very good black sand. } " " " " } ..	100	26.46	26.46
5	" " " " } " " " " } ..	100	21.82	21.82
10	" " " " } Better black sand } " " " " } ...	100	34.38	34.38
15	" " " " } Not quite so good } Fair black sand } ..	100	11.49	11.49
20	Very little black sand } Coarse red sand } No black sand }	100	2.23	2.23
25	" " " " } " " " " }			
		Average black sand, per foot		19.28

Remarks—

Finished hole 3.45 p.m.

3 bags of sand.

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Log.

Bore hole No. A 19.

Small plain.

Sept. 5, 1913.

Feet.		Raw sand.	Black sand.	Black sand. %
0	Frozen peat.....	100	0.00	0.00
5	Peat.....			
10	Fair black sand.....	100	0.00	0.00
15	Fair black sand.....	100	4.09	4.09
20	" " "	100	13.69	13.69
	" " "			
25	Coarse red sand.....	100	8.90	8.90
Average black sand, per foot.				5.34

Remarks—

Finished hole 8.35 a.m.

Moved to Z.A. 18-19. Set up.

2 bags of sand.

Bore hole. Number.	Depth of hole. Feet.	Concentrate. Average % per foot.	Remarks.
D. 11	40	14.75	In old river bed. " " " " 32.63% in first 5 feet.
D.E. 10-11	20	6.56	
D. 10	30	14.76	
D.E. 9-10	25	6.43	
D. 9	25	9.14	
C.D. 8-9	30	9.05	
D. 8	30	7.95	
D. 7	15	1.32	
D.E. 6-7	15	0.51	
E. 7	15	11.87	
D.E. 7-8	40	10.82	
E.F. 7-8	20	17.36	
E. 8	25	6.36	
D.E. 8-9	25	8.75	
E.F. 8-9	20	6.59	
E. 9	30	4.75	
E.F. 9-10	20	11.75	
E. 10	25	5.11	
E.F. 11-12	25	19.28	
E. 12	30	13.99	
E.F. 12-13	20	24.99	
F. 13	20	12.63	
F. 12	20	10.39	
F.G. 13-14	20	6.48	
F.G. 12-13	20	6.97	
G. 12	20	4.01	
G.H. 11-12	30	3.56	
F.G. 11-12	20	7.63	
F. 12	25	4.44	
F. 11	25	11.76	
F.G. 10-11	20	5.25	
G. 11	20	4.53	

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Bore hole. Number.	Depth of hole. Feet.	Concentrate. Average % per foot.	Remarks.
G.H. 10-11	20	3.37	
H. 10	20	9.38	
G.H. 9-10	20	3.10	
G. 10	20	2.68	
F.G. 9-10	25	6.35	
F. 10	25	12.50	
F. 9	20	8.58	
F.G. 8-9	25	4.77	
G. 9	20	3.26	
G.H. 8-9	25	2.35	
H. 9	20	4.28	
H.I. 9-10	20	7.18	
I. 9	20	2.06	
I. 8	20	2.32	
I.J. 7-8	20	1.51	
H.I. 7-8	20	4.16	
H. 8	25	1.93	
G.H. 7-8	25	1.48	
G. 8	20	3.54	
F.G. 7-8	25	2.21	
F. 8	25	11.13	
F. 7	25	9.46	
E.F. 6-7	25	8.78	
F. 6	20	11.10	
F.G. 6-7	20	3.87	
G. 7	25	4.46	
G. 6	20	4.55	
F.G. 5-6	25	5.97	
G. 5	20	2.73	
G.H. 5-6	25	1.92	
H. 5	25	1.78	
G.H. 4-5	20	2.76	
H. 4	25	4.30	
H.I. 4-5	25	1.89	
I. 4	30	2.75	
H.I. 3-4	25	5.30	
I. 3	25	9.24	
I. 2	15	0.65	In old river bed.
I.J. 1-2	20	0.35	" " " "
J. 2	25	1.66	
I.J. 2-3	20	3.06	
J. 3	25	1.69	
I.J. 3-4	20	3.75	
J. 4	20	1.90	
I.J. 4-5	25	4.53	
I. 5	25	9.07	
H.I. 5-6	20	2.27	
H. 6	20	2.24	
G.H. 6-7	20	1.56	
H. 7	20	1.88	
H.I. 6-7	25	2.97	
I. 7	20	6.11	
I. 6	25	9.89	
I.J. 6-7	20	1.10	
J. 7	25	4.48	
J. 6	20	0.70	
I.J. 5-6	25	1.64	
J.K. 5-6	20	2.39	
J. 5	25	1.06	
J.K. 4-5	15	2.11	
K. 4	30	2.86	

Bore hole. Number.	Depth of hole. Feet.	Concentrate Average % per foot.	Remarks.
J.K. 3-4	30	1.66	
K. 3	30	3.74	
J.K. 2-3	22	1.17	
K.L. 2-3	20	3.12	
C. 17	20	3.88	
C. 18	15	7.42	
B. 18	25	8.53	
B.C. 18-19	25	11.22	
B. 19	20	6.75	
A.B. 19-20	25	5.41	
A. 20	32	6.89	
A.B. 20-21	25	5.05	First 5 feet through peat not calculated.
A. 21	25	5.57	" 10 " " " " "
2A. 20-21	25	0.42	" 10 " " " " "
2A. 19-20	25	0.15	" 10 " " " " "
A. 19	25	5.34	" 10 " " " " "
Z.A. 18-19	30	6.35	
A.B. 18-19	20	9.02	
A. 18	25	2.19	" 10 " " " " "
2A. 17-18	25	4.11	" 8 " " " " "
2A. 16-17	25	1.66	" 5 " " " " "
Z. 17	25	8.14	
Y.Z. 16-17	25	0.28	" 5 " " " " "
Z. 16	25	2.67	" 5 " " " " "
Y.Z. 15-16	30	0.21	" 5 " " " " "
Y. 15	20	0.19	" 7 " " " " "
X.Y. 14-15	20	0.15	" 5 " " " " "
Y.Z. 14-15	20	1.12	" 5 " " " " "
Z.A. 14-15	20	1.16	" 5 " " " " "
A. 14	20	9.76	" 5 " " " " "
A. 15	25	7.90	
Z.A. 15-16	20	2.23	" 8 " " " " "
A. 16	25	7.28	
A. 17	25	2.35	" 9 " " " " "
A.B. 17-18	15	2.75	
B.C. 17-18	20	11.72	
B. 17	25	6.43	
A.B. 16-17	15	2.75	
B.C. 16-17	15	10.11	
B. 16	25	6.93	
B.C. 15-16	25	2.06	
A.B. 15-16	25	1.60	
B. 15	20	9.36	
B.C. 14-15	25	1.78	First 9 feet through peat not calculated.
A.B. 14-15	25	9.64	" 7 " " " " "
B. 14	25	7.66	" 8 " " " " "
A.B. 13-14	20	1.97	" 8 " " " " "
A.B. 12-13	20	2.20	" 8 " " " " "
B. 13	20	6.62	" 8 " " " " "
B.C. 13-14	25	7.88	" 5 " " " " "
B.C. 12-13	20	1.55	" 10 " " " " "
B.C. 11-12	20	1.89	" 8 " " " " "
B.C. 10-11	20	4.42	" 7 " " " " "

SESSIONAL PAPER No. 26a

INVESTIGATION OF PROCESSES FOR SMELTING ZINC ORES.

(Mr. W. R. Ingalls, of New York, has submitted the following Report of progress).

Early in 1913, we succeeded in developing at McGill University an electric zinc smelting furnace which gave encouraging results, operating at the rate of 200 to 250 lbs. of charge per 24 hours. A series of runs was made with substantially confirmatory results. With so small a furnace it is impossible to obtain reliable quantitative figures, nor is that possible within the time limits of any run that can be performed in the ordinary laboratory. After the tests to which I refer, it appeared that it was advisable to graduate from the laboratory stage and try things on a larger scale, and so I recommended. Steps were then taken to begin experimental work in the plant built by the Canada Zinc Company at Nelson, B. C., and the right to make use of that plant was obtained from the British Columbia government, which was in possession of it.

About this time overtures were made to the Department of Mines by an American Company which had been for several years engaged in experimental work in electric zinc smelting in the United States. This company expressed a desire to acquire the Nelson plant and continue its experimentation there, with a view to developing it into a commercial plant. This being the ultimate purpose in view by the Department of Mines, the overtures were favourably entertained. Upon instructions I visited the experimental plant in the United States and saw an electric furnace in operation there, and reported to you favourably as to the status of the experimental work there and the advisability of relinquishing the Nelson plant under conditions adequately safeguarding Canadian interests. Negotiations were subsequently inaugurated, but finally failed because of impossibility of giving an option to purchase the Nelson plant, which was made an essential condition by the American company.

A good deal of time was lost by these negotiations. Having failed, the Department of Mines took steps to begin work at Nelson, and drawings for a furnace of estimated capacity of about 2,000 lbs. of charge daily were prepared.

About this time, Dr. Alfred Stansfield retired from the investigation. Mr. E. Dedolph was sent to Nelson to report respecting the condition of the plant there, and to take initial steps to put it in working condition. Mr. D. C. Paleologue was engaged as electro-metallurgist, and was occupied at first in Ottawa in preparing detailed drawings. Soon afterward, Mr. George C. Mackenzie, Chief of the Metallurgical Division of the Department of Mines, was detailed to take full charge of the execution of work at Nelson. He arrived at Nelson on October 9, and immediately began furnace construction.

The plans that have been carried out comprised the construction of a pre-heating furnace, of an electric smelting furnace, and of a little plant to make zinc oxide. Construction was retarded by the delay in obtaining necessary material and parts of apparatus in so remote a place as Nelson, many of these parts having to be made especially. However, at the end of 1913 the oxide plant had been completed and was ready to go in operation within a few days, while the electric smelting plant was but little behind the oxide plant in point of time.

Electric zinc smelting has become a commercially practiced metallurgic art in Sweden and Norway, where the production of spelter in this way amounted to 17,000 long tons in 1913, compared with 8,000 long tons in 1912. While I have not definite information, I am under the impression that the larger part of this output has been derived from the resmelting of dross and other metallic by-products or waste products. However, I believe that some ore is smelted. Unfortunately, Canadian conditions do not permit a transplanting of Scandinavian practice with any reasonable promise of success.

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I believe that there remains no doubt respecting the ability to run an electric zinc smelting furnace, yielding spelter with a satisfactory condensation, matte and lead bullion from the same operation. Difficulties will undoubtedly be experienced in operating the furnace at Nelson, which will necessitate alterations to conform to conditions that will develop in work upon a larger scale than we have yet tried. I am hopeful, however, that such difficulties may be overcome by relatively quick steps.

Yours respectfully,

(Signed) W. R. INGALLS,

Consulting Engineer.

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RESEARCHES ON COBALT AND COBALT ALLOYS AT THE RE-
SEARCH LABORATORY OF APPLIED ELECTRO-CHEMISTRY
AND METALLURGY, SCHOOL OF MINING, QUEENS UNI-
VERSITY, KINGSTON, ONT., FOR THE MINES BRANCH,
DEPARTMENT OF MINES, CANADA,
JANUARY, 1914.

Herbert T. Kalmus.

The investigations of cobalt and its alloys, for the purpose of extending the industrial uses of this metal, have been continued at these laboratories without interruption, during the year 1913. The arrangement between the Mines Branch and the School of Mining, Queens University, Kingston, Ont., according to the terms of which these researches have been conducted, was abundantly set forth in the Summary Report on the Mines Branch, 1911, pp. 27-30.

A preliminary report of the work up to January, 1913, was published in the Summary Report of the Mines Branch, 1912, pp. 94-120.

During the year 1913, the investigations have been greatly extended, and have attracted a large amount of attention among the metallurgical industries that are likely to be consumers of the metal.

The staff of the laboratory, during the past year, has consisted of from one to three research associates and assistants, an analyst, and a mechanic.

The general investigation of the metal cobalt and its alloys, has been and is being conducted along these general lines:—

- I. The Preparation of Metallic Cobalt by Reduction of the Oxide.
- II. A Study of the Physical Properties of the Metal Cobalt.
- III. Electro-plating with Cobalt and its Alloys.
- IV. Cobalt Alloys of Extreme Hardness.
- V. Cobalt Alloys with Non-Corrosive Properties.
- VI. Cobalt Steels.

During the past years, Parts I and II of the above have been completed, and experimental work on each of the other parts extended, so that the experimental work for them all should be finished by the end of the present year, 1914.

THE PREPARATION OF METALLIC COBALT BY REDUCTION OF THE OXIDE.

The report, Part I, "The Preparation of Metallic Cobalt by Reduction of the Oxide," was completed in August, 1913, and is now in press; it is expected that it will be issued about February 1st, 1914.

The purposes of the investigations under Part I were to determine the metallurgical and chemical conditions for the commercial preparation of the metal cobalt from commercial cobalt oxide; that is, to study the speed and the economy of the reactions at various temperatures for:—

- I. Reduction of Co_3O_4 with carbon.
- II. Reduction of Co_3O_4 with hydrogen gas.
- III. Reduction of Co_3O_4 with carbon monoxide gas.
- IV. Reduction of Co_3O_4 with aluminium.

Incidental to this, a study was made of the properties of some of the oxides of cobalt.

The conclusions from this investigation, "Preparation of Metallic Cobalt by Reduction of the Oxide," are:—

REDUCTION WITH CARBON.

I. Reduction of Co_3O_4 with powdered anthracite coal does not take place rapidly so as to make it commercially interesting, either in the oil fired crucible type or furnace or in the electric crucible type of furnace, until a temperature in the neighbourhood of $1,200^\circ\text{C}$ is reached.

II. In either the oil fired crucible type of furnace or in the electric crucible type of furnace, substantially complete yields of metallic cobalt may be obtained by reduction of Co_3O_4 with powdered anthracite coal, in the neighbourhood of $1,200^\circ\text{C}$., for not more than one hour, with subsequent rapid melting and pouring.

III. With the oil fired crucible furnace, using unlined graphite crucibles, complete yields are only obtained with powdered anthracite coal when there is an excess of approximately 10 per cent of this latter.

IV. With the electric crucible type of furnace, used by us, complete reduction may be obtained using only the theoretical quantity of powdered anthracite coal. In this furnace there is a considerable reduction due to the carbon monoxide atmosphere caused by the carbon resister plates.

V. Both in the oil fired and in the electric crucible type of furnace, greater reductions of Co_3O_4 are obtained, using powdered charcoal, than with powdered anthracite at the corresponding temperature.

VI. With the oil fired or electric crucible type of furnace, complete reduction may be obtained with powdered charcoal at 900°C . or higher. For this reduction a considerable excess of charcoal was required, under our conditions from 20-30 per cent.

VII. Powdered lampblack shows results in accordance with those for powdered charcoal.

VIII. Briquetting the charges with an organic binder, tends to increase the rate of reduction at all temperatures. A minimum of about 800°C . may be employed for the reduction of Co_3O_4 with charcoal in the form of briquettes, as against 900°C . for the same charge in bulk.

IX. With sufficient carbon to get a complete yield of metal, the final product need only contain about 0.20 per cent of carbon.

X. At this laboratory, in electric furnaces not especially designed for this work, we reduce enough oxide to make 56 lbs. of the metal in an eight hour day, with the furnace absorbing 12 KW. Thus, on a commercial basis, the power charge for this reduction would be small.

REDUCTION WITH HYDROGEN.

XI. The reduction of Co_3O_4 to metallic cobalt by hydrogen gas takes place very rapidly at all temperatures above 500°C .

XII. At temperatures between 500°C . and 700°C ., over 90 per cent of the reduction of Co_3O_4 to Co takes place in a few minutes, but a further reduction takes place very slowly, if at all.

XIII. Between 700°C . and $1,100^\circ\text{C}$., the amount of reduction of Co_3O_4 to Co which takes place during the first few minutes increases very rapidly, and at the higher temperatures it is complete.

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XIV. The hydrogen reduction method is to be especially recommended for the production of moderate quantities of very pure carbon-free cobalt for special purposes, just as it has been used for the production of metallic tungsten.

XV. For the production of cobalt from Co_3O_4 by hydrogen, the charge must be completely cooled in an atmosphere of hydrogen.

REDUCTION WITH CARBON MONOXIDE.

XVI. The reduction of Co_3O_4 to metallic cobalt by carbon monoxide gas takes place very rapidly at all temperatures above 600°C .

XVII. Between 350°C . and 450°C ., carbon monoxide at first reduces Co_3O_4 to cobalt, but after a time the finely divided cobalt decomposes the CO gas, depositing carbon.

XVIII. At temperatures between 500°C . and 750°C ., over 90 per cent of the reduction of Co_3O_4 to Co, takes place in a few minutes, but a further reduction to completion takes place very slowly.

XIX. Between 750°C . and 900°C ., the amount of reduction of Co_3O_4 to Co which takes place during the first few minutes increases very rapidly, and at the higher temperatures it is complete.

XX. Where producer gas is available, it should offer a cheap and efficient means of producing large quantities of pure metallic cobalt from the oxide.

XXI. For the production of cobalt from Co_3O_4 by CO, the charge must be completely cooled in an atmosphere of CO.

REDUCTION WITH ALUMINIUM.

XXII. The aluminium reduction method can obviously be used with considerable satisfaction where absolutely carbon free metal is required, and where a considerable cost is not prohibitive. Moreover, it affords a method of preparing cobalt-aluminium alloys at once by adding an excess of metallic aluminium.

XXIII. The price of crude aluminium, such as might be used for this purpose, is in the neighbourhood of 14 cents per pound. One pound of aluminium will reduce and melt in this way a little over two pounds of metallic cobalt. Therefore, there is a charge of 14 cents in the form of one pound of metallic aluminium for the power for reducing and melting two pounds of metallic cobalt. There might, of course, be some return for the fused aluminium oxide which resulted from the process, but even allowing liberally for this, the costs are very high as compared with the carbon and CO method of reduction.

THE PHYSICAL PROPERTIES OF THE METAL COBALT.

The experimental work for Part II, "The Physical Properties of Metallic Cobalt," has been completed during the year 1913, and the manuscript is ready for press. The physical properties of both "commercial cobalt" and pure cobalt have been studied. By "commercial cobalt" we mean metal of the grade that could be obtained by the process as described under Part I, without special precautions and under commercial conditions. By pure cobalt in this report, we mean a metal in the neighbourhood of 99.8 per cent—100 per cent Co.

Careful measurements and studies have been made for these metals, as well as a review of the literature, of the following properties:—

1. Colour.
2. Specific Gravity-Density.
3. Hardness.
4. Specific Heat.

5. Melting Point.
6. Magnetic Permeability.
7. Tensile Strength.
8. Compressive Strength.
9. Electrical Conductivity.
10. Optical Reflecting Power.

As a result of these studies of the physical properties of cobalt, it has become apparent that it is not nearly so closely identical with nickel in its properties as has been commonly considered.

Colour.

Pure cobalt very much resembles nickel in colour, although when plated and polished it usually has a more silvery appearance. Metallic cobalt which has been reduced from the oxide at a sufficiently low temperature is a grey powder.

Specific Gravity-Density.

The density of cast cobalt we have found to be 8.7889 at 20°C., which is very close to that of nickel.

Hardness.

Cobalt is very much harder than nickel, the cast metal having a hardness of about 125 on the Brinell scale of hardness, whereas nickel is correspondingly about 65 on the same scale.

Melting Point.

The melting point of pure cobalt we found to be 1467°C., which is probably accurate to within 5°C., whereas that of nickel is 1435°C. Therefore, so far as its melting point at a high temperature is concerned, cobalt is not very much more difficult to alloy than is nickel.

Magnetic Permeability and Magnetic Alloys.

Cobalt is magnetic at all temperatures up to about 1,100°C. We have found an alloy of cobalt and iron, approximately Fe_2Co , which has a magnetic permeability in strong magnetic fields about 10 per cent higher than the best Swedish soft iron. This has been independently discovered at this laboratory, and by P. Weiss, Zurich, Switzerland.

Tensile and Compressive Strengths of Cobalt.

The tensile and compressive strengths of cobalt are greater than that for any metal with which the writer is familiar; the effect of cobalt on the tensile and compressive strengths of certain alloys and of steel is being studied.

Cobalt Chromium Alloys for Heating Elements.

Cobalt alloys with chromium, and the resulting cochrome may be swaged to form cochrome wires. These are in some respects superior to nichrome wires as heating elements; they are less readily oxidized at high temperatures, and have a higher melting point. They have an electrical resistance not very dif-

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ferent from that of nichrome. Further work is being done along these lines, and as well the thermo-electric properties of cochrome are being studied.

The details of the study of all these properties, and as well of others, are given in detail in the report itself.

Electro Plating of Cobalt and its Alloys.

Cobalt when electro-plated on iron, steel or brass, gives a more adhesive plate with a more silvery appearance than nickel. It seems to be less readily corroded than nickel under ordinary atmospheric conditions and upon handling.

Cobalt will probably find extended use in the plating industries for special purposes, even at a price several times that of nickel, for it may be plated from a considerably more concentrated solution than nickel, and at a much higher current density. We find it possible to deposit cobalt approximately five times as fast as nickel.

We are confirming our plating experiments in co-operation with a commercial plating plant, and a complete report will be published during the coming year as Part III of the above.

COBALT ALLOYS OF EXTREME HARDNESS

Cobalt up to about 15 per cent, alloyed with low carbon steel containing small percentages of chromium and tungsten, yields alloys of extreme hardness and of very superior cutting qualities when used as high speed tool steels. Nickel substituted for cobalt in these alloys does not in any case give the same results.

An extended series of observations is being made on numerous alloys of cobalt with mild steel in the presence of chromium and tungsten or molybdenum, and the resulting products are being tested under practical service conditions.

Since the experiments at this laboratory were started, work along these lines has attracted a large amount of attention both on this continent and abroad. There is at present a very spirited controversy¹ among German steel manufacturers as to the value of cobalt for the preparation of high speed tool steels. Professor G. Schlesinger in Charlottenberg, has made elaborate tests of some of the Becker steels, and has reported upon them with extreme favour. These steels contain about 5 per cent of cobalt. The favourable report upon them was made as the result of competitive tests upon about 25 of the best high speed tool steels.

The conclusions of Professor Schlesinger have been bitterly contested by the manufacturers of the non-cobalt steels, and it is very difficult to decide, from reading the reports of the controversy, which of the contestants is correct.

We discovered the value of cobalt in making alloys for high speed tool steels independently, and we are making the alloys and testing the tools quite independent of the work of the German authorities.

The work in this field leaves little or no doubt, but that alloys of approximately the composition:—

Fe.....	67—	75%
Co.....	5—	8%
Cr.....	4—	6%
W.....	15—	18%
C....	0.70—	0.90%

¹ Stahl und Eisen, June, 1913, pp. 930-939.

" " " July, 1913, pp. 1196-1204.

" " " Aug. 7th, 1913, pp. 1317-1325.

" " " Aug. 14th, 1913, pp. 1363-1366.

yield tool steels of great superiority. We have found that molybdenum may be substituted entirely for tungsten, a fact apparently not noticed by the German investigator.

This tool alloy can be made commercially at a price to compare with that of the best high grade tool steels. It is not to be confused with the alloys of cobalt and chromium of the nature:—

Co.....	60%
Cr.....	20%
Mo or W.....	20%

which also make very superior tool steels, but which can only be made at a very high price. These latter have also been carefully investigated. The entire subject of our investigations on "Cobalt Alloys of Extreme Hardness" will be reported upon during the coming year as Part IV of the series of researches.

COBALT ALLOYS WITH NON-CORROSIVE PROPERTIES.

Small percentages of cobalt added to pure iron give alloys which are extremely non-corrosive and which will probably find extended use as sheet roofing materials. These have been abundantly tested by us on a laboratory scale, and are at present being tested on a commercial scale.

In co-operation with one of the large rolling mills, we have made three four-ton heats of cobalt-containing alloys, and two four-ton heats of standard materials for comparison. These analysed as follows:—

NON-CORROSIVE COBALT ALLOYS FOR SHEET ROOFING MATERIALS.

Heat No.	Sulphur.	Phos.	Carbon.	Manganese	Copper.	Nickel.	Cobalt.
34,175	.026	.009	.010	.022	.016		
34,185	.034	.006	.015	.017	.028		1.18
34,196	.040	.008	.010	.020	.024		.60
34,204	.022	.009	.010	.020	.020		.35
44,009	.025	.008	.01	.015	.24	.75	

One bar of each of these alloys is at present in transit, as well as two sheets of each rolled into corrugated roofing material, 26" X 36" X 96" in size, box annealed, for the purpose of making corrosion tests at this laboratory. Arrangements are made for accelerated corrosion tests on small samples from the bars, and the large sheets will be exposed to atmospheric conditions over a period of months, to check the results with similar tests being made at the plant. The sample from Heat No. 34175 is a standard pure iron sheet roofing material, now very extensively used. It, together with the nickel alloy, Heat No. 44009, will serve as standards of comparison for these corrosion tests.

In addition to the above we are receiving ladle tests, taken when the heat was tapped, so that we may check the analyses made at the rolling mill with our own.

A complete report of the work on non-corrosive cobalt alloys will be made during the coming year as Part V of the above.

NOTES ON COBALT INDUSTRY.

The cobalt-oxide industry is a very old one. It probably started, on what might be considered a commercial scale, at Schneeberg, Germany, in 1520; about this time "blue cobalt," cobalt smalt, from Schneeberg, was being sold at

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Venice. The smalt contained about 6 per cent of cobalt. The smalt industry has a very interesting history in Saxony and Bohemia during the sixteenth to eighteenth centuries, during which time it grew very rapidly. F. Kapff, Finance Minister of Prussia, made a report of the industry in 1792, in which he estimated that 30 smalt works were at that time putting out 3,000 tons of smalt per year.

At the present time these German and Austrian mines are important for bismuth and radio-active materials, the silver and cobalt having become quite insignificant. The historical development of this German silver-cobalt district is interesting because it probably forecasts the history of the present Ontario silver-cobalt camp, in that the production of cobalt continued over a long period after the camp had been depleted of its silver values.

During later years, up to 1904-05, New Caledonia, New South Wales, Chili, Spain, Norway, and Prussia, supplied the world with cobalt. The output of New Caledonia at the time the Ontario deposits were discovered was probably 85-90 per cent of the world's supply. In 1904, Mr. A. Glasser, "Report in 1904, to the Minister of the Colonies, on the Mineral Wealth of New Caledonia," stated that New Caledonia had practically the monopoly for the production of cobalt for the whole world. The ores were not smelted or refined in New Caledonia, but were shipped to Europe to be treated.

The silver-cobalt mines of Ontario began to produce in 1904, and since that time they have wrested the monopoly in the production of cobalt from New Caledonia. The price offered for the CoO content of New Caledonia ores, running 8 per cent in CoO, had fallen from about 85 cents per pound in 1904, to approximately 20 cts. per pound in 1908.

Until the last year about one-half the ore from the Cobalt camp found its way to United States smelters. The ore is siliceous and mixes well with United States basic ores. So far as the writer is aware, the cobalt content of the ore shipped to the United States has never been recovered to any extent. The present United States practice leaves it in the form of residues, containing Pb, Cu, As, Sb, S, Ni, Fe, Ag, and Au, that is, in rather bad shape to be treated for cobalt.

Until the last year or so, practically the only way which cobalt found its way into the industries was as cobalt oxide, Co_3O_4 , for use as blue colouring substance. During the last few years the production of cobalt from the Ontario mines much exceeded the consumption of cobalt as cobalt oxide. The writer reported¹, January, 1913, that the cobalt oxide industry consumed about one-third of the present output of the camp. During the last year the demand for cobalt oxide has considerably increased so that, although the cobalt output of the Ontario mines is still very much in excess of the consumption of the metal cobalt, it is no longer true to the degree stated above. A considerable amount of statistical work would be required to make an accurate estimate of the present cobalt content of the output of the Canadian mines, but the writer considers 1,000 tons of cobalt metal per year to be a fair rough working figure.

It is to be noted that since the experiments commenced at this laboratory, cobalt has begun to find its way into the industries as metal reduced from the oxide, largely for use in making alloys.

It can never be known to just what extent the efforts of this laboratory have been responsible, directly or indirectly, for the increasing economic importance of metallic cobalt. In this connexion we have been particularly active in encouraging others to interest themselves to find industrial uses for cobalt, and to this end we have answered a very large number of inquiries concerning the metal, and have prepared and distributed a considerable number of samples. In addition, we have emphasized the possibilities of the metal, by presenting certain features of the work at the meetings of various engineering and scientific

¹ Summary Report of the Mines Branch, of the Canadian Department of Mines, for the year 1912, p. 94.

societies. Inasmuch as at the present time practically the sole source for cobalt is from the Canadian mines, we have felt that we were justified in encouraging a study of any possible use of the metal wherever an interest was demonstrated in it.

The fact that such a large range of work, with an enormous amount of detailed investigation and observation, has been accomplished during the two years of operation of this laboratory, is largely due to the untiring enthusiasm and splendid spirit of the staff of assistants at the laboratory, and in particular to the efforts of Mr. Chas. Harper, in the capacity of research associate.

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FUEL TESTING DIVISION.

I.

WORK AT FUEL TESTING STATION.

B. F. Haanel.

Chief of Division.

The work of the Fuel Testing Division, during the year 1913, consisted in the investigation of the five commercial samples of lignite obtained from the following producing mines: Cardiff Collieries, Ltd; Gainford Coal Co., Ltd.; Twin City Coal Co., Ltd.; Tofield Coal Co., Ltd.; and the Rosedale Coal and Clay Products, Ltd. In addition to the actual work of conducting this investigation, which involved the complete chemical analyses of general samples of the various coals, the determination of their heating values and the analyses at regular intervals of the gas produced, and determination of the tar and ammonia contained in the final gas; many samples of various fuels were examined in the chemical laboratory. Owing to the very limited staff at the disposal of this division, the working up of the various results of the tests for publication has taken a much longer time than is desirable. The value of reports of this character, to those who are interested, is dependent, to a large extent, on the promptness with which they are got out. In order, therefore, to carry out with the desired degree of promptness the work of this division which entails routine work, the answering of correspondence, and the necessary travelling at times of the chief of the division as well as others of the staff, additional chemists and technical engineers are urgently required. Moreover, on account of the alterations to the Fuel Testing Station, and the building of the Ore Dressing and Concentration laboratory, which were not completed until towards the middle of the year 1913, the work of investigating the coals in question was unavoidably delayed until the summer of the same year. The experimental steam boiler, in fact, was not installed until late in December of 1913, so that the results of the tests of these coals when burned under a boiler cannot be included in this report, since they were not completed until the beginning of the new fiscal year 1914.

The producer tests conducted with these coals, the results of which are contained in this report, proved satisfactory in almost every respect. All the coals tested were fed in the producer without undergoing any preliminary treatment, e.g., as crushing or screening, and although certain of the coals had deteriorated considerably during their long period of storage this in no manner affected their behaviour in the producer. As far as producer work is concerned, the disintegration of the lignites utilized is of little consequence, and, even though not exposed to the weather or stored under cover for a long period, such disintegration, as a general rule, is effected as soon as this fuel is exposed to high temperature.

The tendency of a lignite fuel to disintegrate into finely divided particles is almost directly dependent on its moisture content when mined—but this does not strictly hold in all cases. The sample of coal obtained from the Rosedale Coal and Clay Products, Ltd., was somewhat remarkable, in that it exhibited scarcely any tendency to disintegrate either on exposure to the weather or when subjected to the temperatures prevailing in the producer. On the other hand, this particular coal exhibited a marked tendency to clinker. As far as the calorific value and moisture contents of the various fuels, as fired, are concerned, they may be said to be eminently suitable for producer work. The complete record of analyses of the coals as fired, the calorific value of the gas produced, and all other data will be found in the annexed report.

The duties of the writer during the past year consisted, in addition to the general office duties, correspondence, etc., and the directing of the laboratories of the Fuel Testing Station, in the writing of the Report entitled "Peat, Lignite, and Coal, their Value as Fuels for the Production of a Power Gas in the By-Product Recovery Producer," which is based on the results obtained during the investigation of the various by-products recovery producer gas plants in operation in Europe.

As a result of this investigation, the writer was able to show that, under certain favourable conditions, peat fuel for the production of a power or fuel gas, when accompanied by the recovery of its nitrogen content, can be economically utilized. The conditions on which the successful utilization of peat for this purpose depends are: 1st., a cost of the peat fuel containing not more than 40 per cent, but preferably not more than 30 per cent of moisture, of not more than \$1.50 per ton delivered at the producers—this cost of course is variable to a certain extent and depends on the cost at which coal containing a suitable percentage of nitrogen can be obtained, and 2nd., a minimum nitrogen content of not less than $1\frac{1}{2}$ per cent on the absolutely dry sample. For the utilization of coal containing 1 per cent and above, of nitrogen, this process has proven very successful, and plants of very large capacity are and have been for several years in successful operation. In the case of the South Staffordshire Mond Gas Co., the gas produced is delivered through gas mains laid by the company over a large area to industrial works of all kinds and the scope of utility for such a gas would be very greatly increased were its use for domestic purposes not prohibited by a parliamentary Act regulating the distribution through pipes of town or retort gas. In certain of the more populated portions of the western provinces, the utilization of lignite for the production of a fuel gas for domestic or other purposes, might prove an entirely feasible proposition. There is no reason why the Canadian lignites should not prove as suitable a fuel for this type of producer as either coal or peat. Indeed, if such a scheme were successfully put into effect, the problem of supplying a satisfactory and cheap domestic fuel to many of the cities of our prairie provinces would be effectively solved, and the imports of foreign coal would be materially reduced. This report is in the press and will shortly be ready for distribution.

In accordance with the plan of work outlined for the Division of Fuels and Fuel Testing, about twelve commercial samples of lignite from various portions of the western provinces will be sent to Ottawa for complete investigation during the next year. Of these samples three have already been received while three more are en route. The scope of this investigation, it is confidently hoped, will be extended to include the briquetting of lignites, and their fractional distillation for the recovery of oils and other by-products.

The report of Mr. A. von Anrep, peat expert, is subjoined herewith, as is also that of Mr. Edgar Stansfield, the Chief Chemist of the Division of Fuels and Fuel Testing.

During the year the personnel of this division has been increased by the permanent appointment of Dr. F. E. Carter, Engineering Chemist.

New Apparatus. A Babcock and Wilcox marine boiler of about 200 H.P. capacity has been installed for the purpose of conducting steam tests with the various samples of coal received. This boiler is equipped with a sirocco induced draft system, and is replete with the necessary feed water pumps, weighing tanks, etc.

Machine shop. The machine shop, which is under the direct supervision of this division, is now equipped with a Brown and Sharpe milling machine, Pratt and Whitney lathe, Brown and Sharpe grinding machine, one press drill and one precision drill. All of the above machines are operated by individual motors. It

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is hoped during the coming year to install a shaper which is almost indispensable where much repair work is to be done. A large part of the plant for the Ore Dressing and Concentrating laboratory, as well as certain pieces or parts of machinery for the Fuel Testing laboratories, have been made in this shop—for which a special machinist has been engaged. A machine shop is an absolutely indispensable adjunct to experimental laboratories of this character where it is necessary to have constructed from time to time new pieces of apparatus or to alter or repair existing machines or apparatus.

The report containing the results of the tests of the five commercial samples of lignitic coals received from the operating mines, previously mentioned, is here-with subjoined. This report has been prepared by Mr. Blizzard and the writer, and will be published in bulletin form as soon as the results of the boiler tests are worked out.

II.

RESULTS OF THE INVESTIGATION OF FIVE LIGNITE SAMPLES OBTAINED FROM THE PROVINCE OF ALBERTA.

B. F. Haanel and John Blizzard.

TYPES OF PRODUCERS EMPLOYED IN THE TESTS.

The two producers employed in these tests were evolved from the simple up-draft type or from a combination of this with the simple down-draft type.

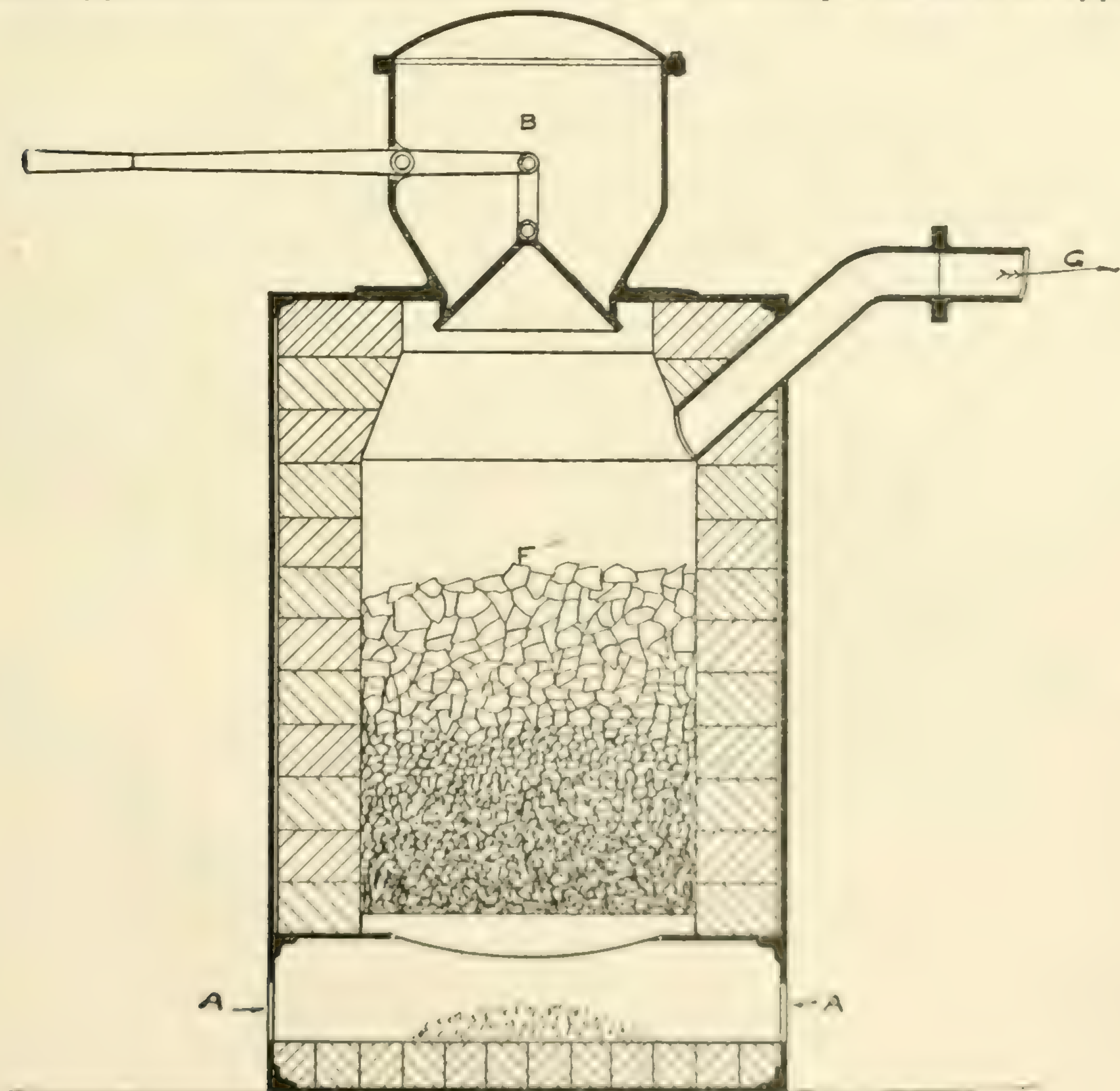


Fig. 6. Simple form of up-draft coal producer.

Up-draft Producers. A simple form of this type of producer is shown in Fig. 6, which clearly illustrates the principle of operation. The fuel is charged

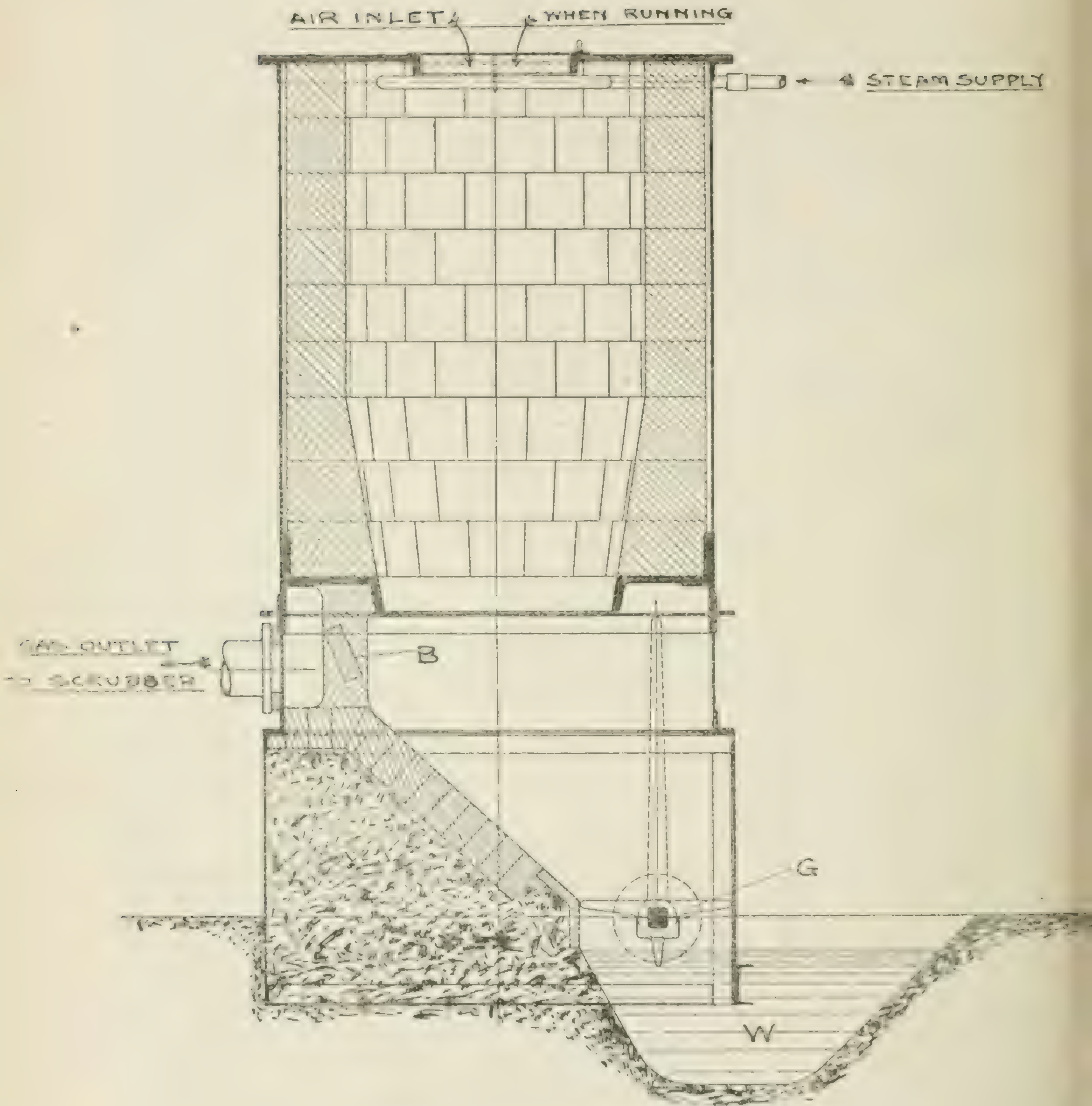


Fig. 7. Simple form of down-draft gas producer.

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through B and the air and steam required for combustion are admitted through A below the fire bars. The gas offtake is situated near the top of the producer at G which is placed at a considerable distance above the fuel level. The air and steam in passing upwards through the reaction zone interact with the hot carbon and a combustible gas is thus formed which leaves by the exit G. It will be seen that the tarry matter which is distilled from the fuel, passes off with the gas without coming into contact with the carbon in the combustion zone, consequently, it takes no part whatever in the formation of the final gas. If, therefore, a large proportion of the total heating value of the fuel is contained in such tarry matter, the thermal efficiency of the process will be very low, since this matter, as pointed out, leaves the producer undecomposed. In addition to the inefficient manner in which such a producer converts the heat of a fuel into a useful gas the fact that the gas is heavily laden with tarry matter, which must be removed by tar extractors before it can be utilized in a gas engine, must not be overlooked. In most cases where a fuel is gasified for the primary purpose of generating power, the formation of tar constitutes a nuisance, and, in order to remove this objection, the down-draft type of producer was devised.

Down-draft Producer. In this type of producer the air, and steam if required, are admitted at the top, and in passing downwards through the reaction zone of the producer, form, by interaction, with carbon, a gas which leaves by an exit situated below the combustion zone. Fig. 7 shows an illustration of a producer of this type which was used for the coal tests carried out at McGill University. The fuel, with this type of producer, is also charged through the top, but since the draft is in a downward direction no gases escape from the charging door. Such an arrangement permits, also, the fuel bed to be poked through this charging door, and the observation of the fire. By referring to Fig. 7, it will be plainly seen that all the volatile matter which is distilled from the fuel must pass down through the hot fuel bed before leaving at the exit situated at or just below the combustion zone; hence it comes into intimate contact with the incandescent carbon of the reaction zone and is either decomposed into permanent gases or is partially burned and partially decomposed. The result, however, as the reaction proceeds, is a gas practically free from tar and a higher thermal efficiency for the process of gasification. With this type of producer an appreciable quantity of combustible matter passes below the gas outlet without being completely burned, and since this cannot, in a practical manner, be recovered, it is lost as far as the process is concerned, and decreases the thermal efficiency of the system. This constitutes the principal objection to this type, though in many other ways such a producer is quite satisfactory.

Combined Up-draft and Down-draft Producer. This type of producer was evolved for the purpose of combining all the advantages of the up and down draft types and at the same time eradicating their objectionable features. It will readily be seen from the following description that with such a producer it is theoretically an easy matter to decompose all the moisture and volatile matter distilled from a fuel and insure the complete combustion of all the combustible matter passing into the lower zone. In such a producer fuel is charged at the top, where air and steam inlets are situated, while additional supplies of air and steam are admitted to the bottom of the lower zone. The gas formed is drawn off at the middle of the producer, hence the final producer gas is a mixture of the gas formed in the upper and lower zones. Although the gas formed in the upper zone is more or less uneven in its composition owing to the charging of green fuel from time to time, the composition of the gas formed in the lower zone can be kept approximately constant, since this zone is operating continu-

ously on the hot coke or carbon of uniform composition, resulting from the coking process going on in the upper zone. From this it follows that by employing two zones in the manner above described, theoretically a gas will be produced, which will be less sensitive as regards its chemical composition, to changes

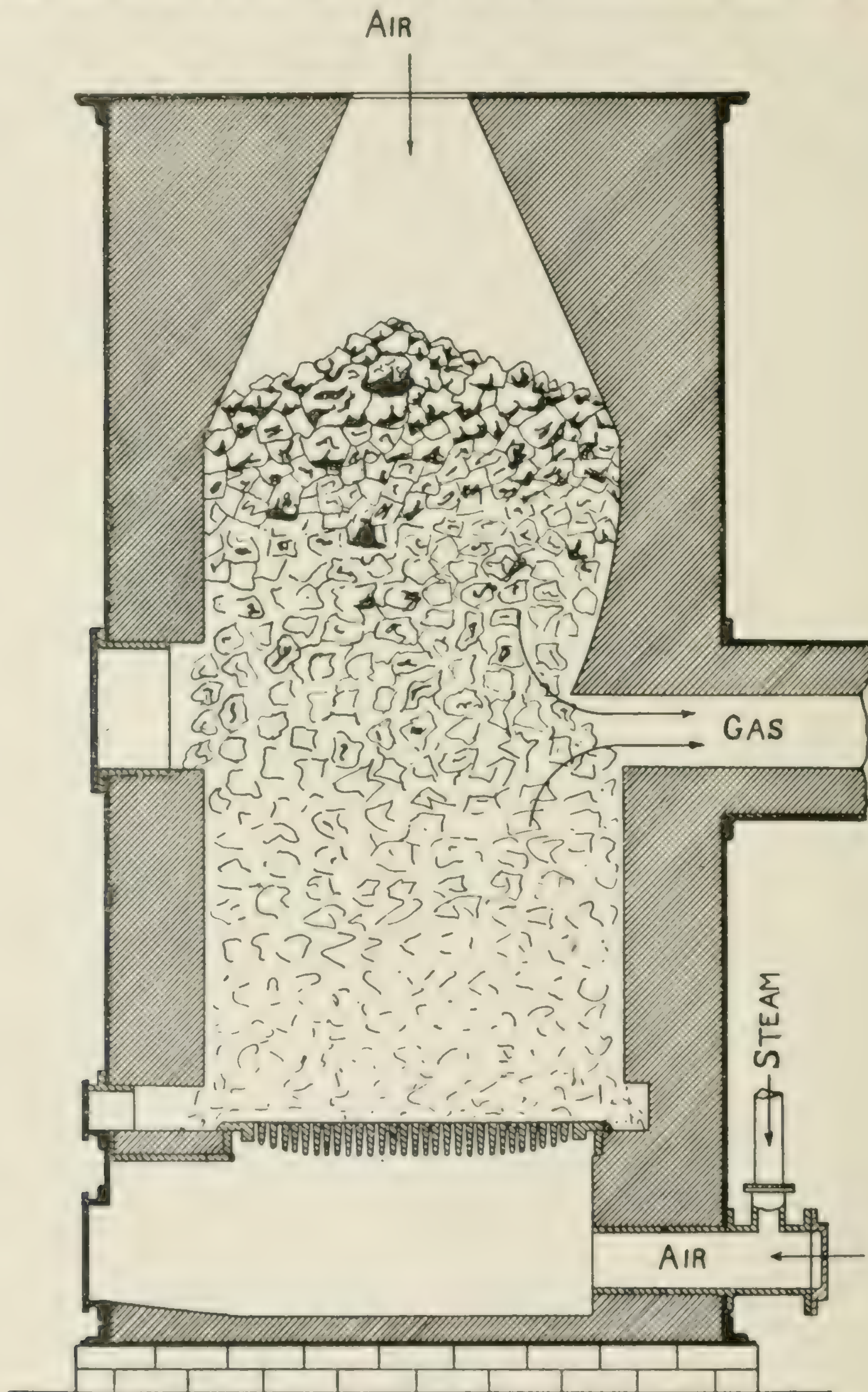


Fig. 8. Combined up-draft and down-draft producer.

taking place in the charging zones. This may be said to constitute still another advantage over the other types of producer previously discussed. A producer constructed upon this principle is shown in Fig. 8.¹

¹ Illustration taken from the Proceedings of the Institution of Mechanical Engineers, 1911.

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The Westinghouse producer employed at the Fuel Testing Station for most of the tests to be described, operates upon precisely the same principle though the construction and method of operation employed in this producer are somewhat different. In short the functions of the two zones of this producer may be described as follows: the upper zone serves the purpose of distilling the moisture and volatile matter from the fuel and thus supplying coke or tar free combustible matter to the lower zone. In this zone gas is also formed from the volatile matter, moisture, and hot carbon interacting in their downward path. In the lower zone the tar free combustible matter or coke, depending on the fuel employed, interacts with the air and steam admitted through the tuyere situated at the bottom of the producer.

Double Zone Producer, both zones operating with up-draft. For the gasification of fuels high in volatile matter and moisture, a producer designed on this principle is very efficient. The Körting double zone peat gas producer, see Fig. 9, is constructed according to this principle. The fuel is charged into hoppers A, A from which it falls on to two sloping grates C, C. Theoretically the combustion in this portion of the producer should be just sufficient to distil the volatile matter and moisture from the green fuel. In practice, however, the fuel consumed here exceeds that theoretically required. The tar free fuel passes through a restricted canal to a second zone situated directly beneath and here combustion is carried to completion. The upper zone gas charged with moisture and tarry matter is caused to pass through the opening D and downcomer E to the chamber F, situated directly beneath the grate bars R of the lower zone. From this point the gases pass upward through the bed of incandescent carbon to the two offtakes J, J, situated on either side of the producer. The formation of producer gas is accomplished almost entirely in the lower zone. Here the gases resulting from the combustion of fuel in the upper zone together with air admitted through openings I, I pass upwards through the hot carbon. As a consequence, reaction takes place between the air, moisture and, to a certain extent, the tarry matter, and the carbon. The moisture is decomposed, forming free hydrogen carbon monoxide and carbon dioxide, while the carbon dioxide contained in the upper zone gases is partially reduced to carbon monoxide. The tarry matter is partly decomposed into permanent combustible gases and is also to a certain extent burned. Theoretically such a process should result in a tar free gas but in actual practice this is never the case, and a tar extractor of some description must be interposed in the system for the purpose of purifying the gas sufficiently for use in the gas engine.

DISCUSSION OF THE COMBINED UP-DRAFT AND DOWN-DRAFT TYPE OF PRODUCER.

This type of producer has been evolved to supply the requirement for a gas generator capable of producing a gas from bituminous coals sufficiently clean for utilization in a gas engine without first passing through the usual train of purifying apparatus. The simple form of down-draft producer, described elsewhere, was a partial solution to the difficulties produced by the presence of tar in the gas—but this type on the other hand possessed certain disadvantages which offset to a certain degree the advantage otherwise gained. Fairly good results were obtained with the down-draft producer used during the trials conducted at McGill University for the Department of Mines. A rotary tar extractor was employed which gave satisfactory results for some of the trials but in others considerable trouble was experienced with tar, which necessitated cleaning of the extractor while the trial was in progress. In the case of lignites, very little or no tar was removed and, in certain instances, the trials were run satisfactorily without using either the tar extractor or a sawdust scrubber—the only cleaning agent being a wet coke scrubber. The efficiency of this producer when

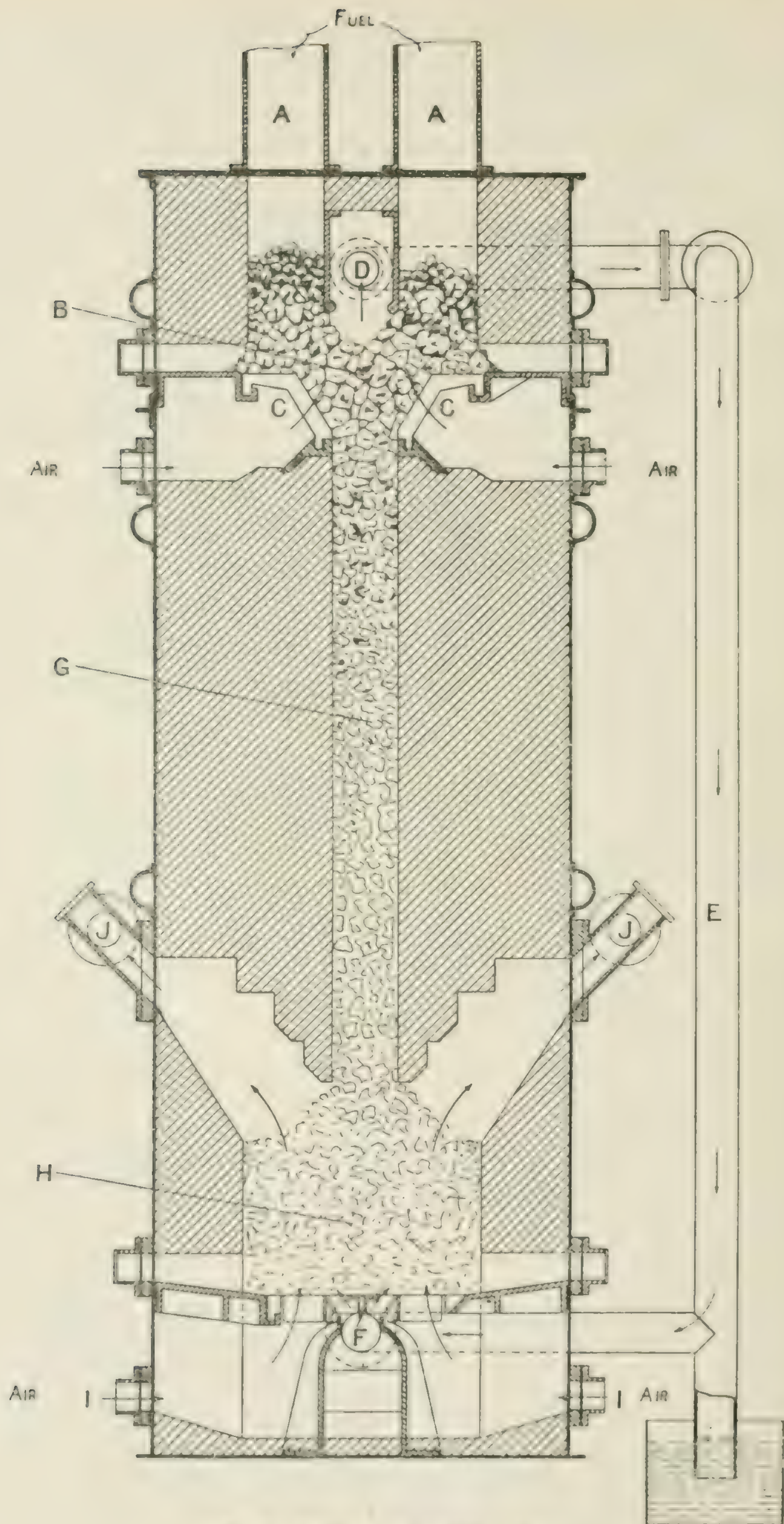


Fig. 9. Double zone up-draft producer.

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gasifying lignitic coals varied between 49·5 and 65·7 per cent, whereas in the trials with the Westinghouse double zone producer at Ottawa on similar fuels, the efficiencies ranged between 62·0 and 71·8 per cent. The better results obtained with this producer may be attributed, partly, to its larger capacity, but more particularly to the fact that the combustible matter passing into the lower zone is more completely burned. The refuse drawn from this simple down-draft producer contained from 44·4 to 53·4 per cent of combustible.

The advantages of the double zone producer over either the simple up-draft or down-draft types may be summarized as follows:—

First.—The practically complete combustion of all the fuel charged.

Second.—The formation of a tar free gas.

Third.—Absence of auxiliary tar extractors or other gas purifying devices.

Fourth.—A final gas composed of a mixture of the gases generated in the two zones of the producer, hence less variation in composition due to charging green fuel, since the gas formed in the lower zone is practically constant as regards its composition.

When a coking bituminous coal is burned in this type of producer, instead of the formation of tar, lamp black is produced, to a greater or less degree, depending on the method of manipulation adopted. This lamp black is readily separated from the gas in its passage through the water scrubber.

Destruction of the Tarry Vapours. The heavier hydrocarbon vapours are either split up into fixed combustible gases, or are burned within the producer itself. Though both of these agencies may be effective to a certain degree, it is quite probable that the major portion of the tarry matter is burned. Where the heavy hydrocarbon vapours are oxidized the products of combustion are carbon dioxide, carbon monoxide, and steam in proportions depending on the temperature. These may again be reduced in their passage through the hot carbon to the offtake. If carbon dioxide, CO_2 , is formed then its reaction with carbon according to the reversible reaction:

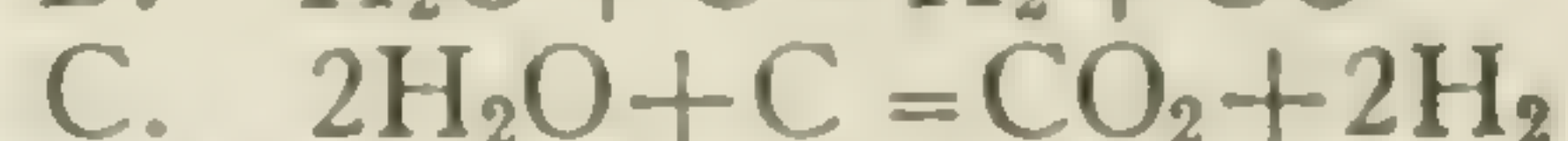
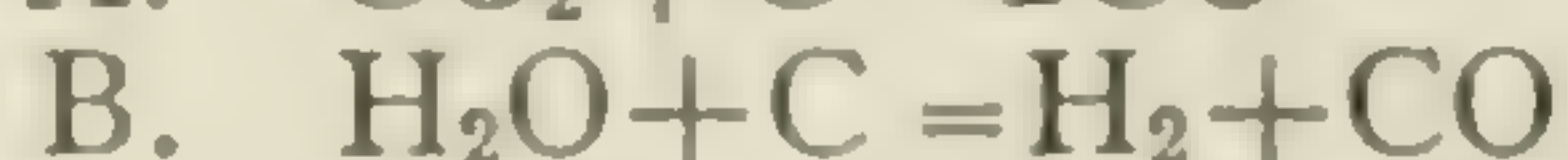
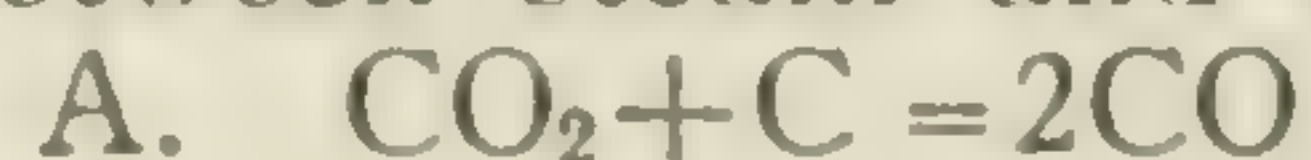


will result in the formation of carbon monoxide, but while this reaction may proceed to a certain degree it is quite likely that a further and reverse reaction takes place and that the carbon monoxide is again decomposed, during its passage through the cooler portion of the fuel bed, into carbon dioxide and free carbon. The observance of this latter reaction is confirmed since free carbon in the form of lamp black is contained in the final gas. Methane also occurs as a component of the gas in more or less variable proportions—but always in comparatively small quantities. It must be borne in mind when considering the reactions which are likely to obtain in any producer that while theoretically the column of fuel can be divided into distinct zones where certain reactions will take place, that in practice no such division can be accurately made owing to the impossibility of maintaining uniform combustion throughout the whole area of the fuel bed. This is due in part to the heterogeneous forms and sizes of the individual pieces of fuel which permit the passage of more air through some portions of the bed than others. Consequently isolated zones of high temperature may exist where least expected and these will to some extent alter the expected reactions.

The combustion of the hydrocarbons as a means of removing the tarry matter will now be considered in more detail. The process of burning the hydrocarbons to carbon dioxide, carbon monoxide and steam renders the process of gasification more simple and makes it an easier matter to approach the ideal condition for a double zone producer, viz., that of delivering only fixed carbon to the lower or up-draft portion. In order that the products formed by the combustion of the tarry matter may be decomposed into combustible gases, it is

necessary that sufficient fixed carbon be present to effect the required reactions.

Before passing on to a description of analyses of the tests, it will be of interest to examine the chemical analyses of the lignites tested as to their suitability for operation under the ideal conditions outlined above. For these conditions it will be assumed that the reactions take place according to two of the following three equations, viz., "A" for the reaction between CO_2 and C, and either "B" or "C" for the reaction between steam and carbon. The chemical reactions are:—



It will further be assumed that "fixed carbon," an empirical term employed by chemists in reporting their analyses of coal, represents pure carbon.

According then to the assumption that carbon dioxide and steam are reduced according to the above, it is evident from A, that 1 lb. of carbon in the volatile matter requires 1 lb. of carbon in the fixed carbon for its subsequent reduction after its combustion to carbon dioxide, and from B, that 1 lb. of hydrogen in the volatile matter requires six pounds of fixed carbon, and from C that one pound of hydrogen requires 3 pounds of fixed carbon.

TABLE I.

Name of coal.	Per 100 lbs. of Fuel as Charged.						
	Fixed carbon per cent in coal as charged.	Carbon in volatile matter.	Hydrogen.	Fixed carbon required to reduce carbon and steam A+B.	Fixed carbon required to reduce carbon and steam A+C.	Surplus fixed carbon.	
						A+B re-action.	A+C re-action.
Tofield.....	36.7	13.7	6.6	53.3	33.5	-16.6	3.2
Rosedale.....	43.4	13.9	5.8	48.7	31.3	- 5.3	12.1
Gainford.....	43.8	10.0	5.0	40.0	25.0	+ 3.8	18.8
Cardiff							
colliery.....	40.4	11.7	6.4	50.1	30.9	- 9.7	9.5
Twin City...	41.3	12.8	5.9	48.2	30.5	- 6.9	10.8

From the above table it will be seen that in one case only, that of the Gainford coal, is there a surplus of fixed carbon after the reactions A and B have been effected. As the reversible reaction $\text{CO}_2 + \text{H}_2 = \text{CO} + \text{H}_2\text{O}$ is constantly taking place, neither B nor C could take place exclusively, in an ordinary producer, but the right hand side of the reversible reaction will predominate as the temperature rises. A further inference from the above table is, that with the exception of the reaction A and B calculated for the Gainford coal, there will be an excess of steam present supplied by the coal itself, after the reactions have been completed. For such fuels, therefore, as those considered it would seem inadvisable to admit steam to the down-draft zone except in those cases where it is desired, for the purposes of operation, to decrease the temperature. Of the eight trials of lignites carried out at McGill University with the simple down-draft producer, steam was introduced in only three cases. The moisture contents of the lignites in these three cases were 16.1; 12.6, and 7.8 per cent respectively. In all the trials described herein, no steam was admitted to the upper zone of the producer.

In the actual operation of a double zone producer it is impossible to completely burn and subsequently reduce the tarry vapours by the methods described. Instead of this perfection being attained, either the products of combustion

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of the tarry vapours are not completely reduced or the tarry vapours leave the producer partly unburned. The successful operation of such a producer will, therefore, lie between the burning and reduction of the volatile matter without permitting an undue proportion of gases to escape in the form of carbon dioxide and steam. By such a method of operation, a practically tar free gas can be obtained.

OBJECT OF TESTS.

The tests were carried out for the purpose of determining; *1st*, the efficiency of the conversion of the fuel into gas; *2nd*, the quality of the gas produced; *3rd*, the amounts of tar present in the gas, and its suitability for use in a gas engine; and *4th*, the difficulties encountered in the operation of the producer.

Other information was obtained such as the quantity of ammonia in the gas, and the quantity of water used for cooling and cleaning the gas, the variation in the efficiency of the producer for the different tests is also accounted for as far as possible. Further, comparison is made possible between the utilization of the fuel in two types of producers.

METHOD OF CARRYING OUT TESTS AND OBSERVATIONS THEREON.

Fuel, Quality, and Composition. The accurate sampling of the fuel charged is an important item in tests of this character, and should be carried out for fuels which change so rapidly as lignite, immediately before a test. The consumption of fuel is determined by accurately weighing all the coal charged and by judging the conditions of the fuel bed at the beginning and end of the test.

Determination of the Quality of the Fuel. Immediately before each trial the fuel to be tested was carefully sampled. For sampling so large a quantity of fuel it was found convenient to employ the 3rd shovel method, i.e. the entire quantity of coal was shovelled over and every third shovelful of coal was thrown into a heap by itself, this was then again reduced in the same manner after crushing, and finally quartered down to a comparatively small sample from which a laboratory sample was taken and put in a sealed jar for further examination. The fuel was in every case charged into the producer without being subjected to any preliminary treatment, e.g., as crushing or screening.

Fuel Charged. The fuel before charging was weighed on a standard scale, and a record was kept of the fuel level during the entire test.

Starting and Stopping the Tests. The producers were started from a small fire, which was gradually built up with an up-draft.

Before starting the trial, gas was drawn off for several hours until conditions became normal. At the beginning of the trial the fuel levels were observed; all ash was removed from the ash pit of the Körting producer, and the ash level adjusted in the Westinghouse producer so that the incandescent fuel was just visible through the lower poke-holes.

Before stopping the tests the conditions in the producer were made to approximate, as far as possible, the conditions obtaining at the beginning. In the case of the Westinghouse producer the judging of its interior condition is almost an impossible matter, and is likely to give rise to serious errors in the estimation of the fuel consumption unless the trial is conducted for a period of sufficient duration to reduce any such errors to a negligibly small percentage of the total fuel charged.

Possible Errors due to change in Fuel Contents at the beginning and end of a test in the Westinghouse Producer. If the average fuel contents of the producer are assumed to weigh 45 lbs. per cubic foot, the total weight of the fuel with this assumption will be 6500 lbs., and since the total fuel charged during the trials varied from 6,215 to 10,881 lbs., it will be seen that the ratio of the fuel in the producer to that charged is very high. In estimating, therefore, the condition

of the fuel in the producer at the beginning and end of a test, a large error may be introduced exceeding sometimes 1000 lbs.—the duration of the test should, therefore, be long enough to reduce the above ratio to such an extent that such an estimate will not introduce an appreciable error.

With a view to checking any serious error in the estimation of the fuel bed two consecutive lines on the summary sheet show the quantities of carbon charged and of that leaving with the gas per hour. In every trial except No. 46 the carbon charged exceeds that leaving with the gas.

In trial No. 46, the fuel contents of the producer have been depleted during the trial to the extent of 340 lbs. of carbon, which seems to point to the fact that there is probably a still greater depletion than this, owing to the carbon being associated with other combustible matter.

The following table calculated for the Westinghouse producer trials shows the efficiency calculated to allow for the difference in the carbon charged and carbon removed as permanent gas.

For purposes of comparison the efficiency representing the ratio of the heat in the gas produced during the trial to that of the coal charged is included in the table.

TABLE II.

Trial	Fuel.	Efficiency. A.	Efficiency. B.
38	Tofield.....	67.5	66.9
39	Tofield.....	62.6	62.0
40	Rosedale.....	66.0	65.2
45	Gainford.....	66.2	65.6
46	Cardiff colliery.....	71.4	71.8
47	Twin City.....	60.9	60.9

Gas Produced.

Quantity. The quantity of gas used was measured by means of a "Rotary Meter." This meter is shown in Fig. 10, and operates on the principle of the anemometer. The working parts consist, principally, of a turbine wheel with vanes set at an angle of about 45 degrees. This wheel is carried by a central shaft, which is pivoted at the top and bottom in jewelled bearings, in order to reduce friction. This shaft actuates the recording mechanism by means of a worm wheel. A series of guides are placed just below the turbine wheel for the purpose of directing the flow of the gases before they impinge on the moving vanes. A light non-return valve at the bottom of the meter prevents a return flow of gas. A small quantity of the gas is by-passed through the tubes, shown to the right and left of the non-return valve, in order to ensure rotation of the turbine at small rates of gas flow.

Calibration of Gas Meter. At the conclusion of the gas producer tests the meter was calibrated. The method employed consisted in comparing the meter readings with calculated volumes based on data obtained from the resistance to flow of air through sharp orifices in thin plates. For this purpose air boxes¹ were employed. The rate of flow was calculated from the formula

$$Q = .0137 \cdot Cd^2 \sqrt{\frac{iP}{T}}$$
 where Q = flow of air in lbs. per second.

C = a coefficient (about .6) found from the above mentioned experiments.
d = diameter of orifice in inches.

¹ Which were of similar construction to those used by Professor R. J. Durley at McGill University, and described by him in a paper (No. 081) read before the American Society of Mechanical Engineers in December, 1905.

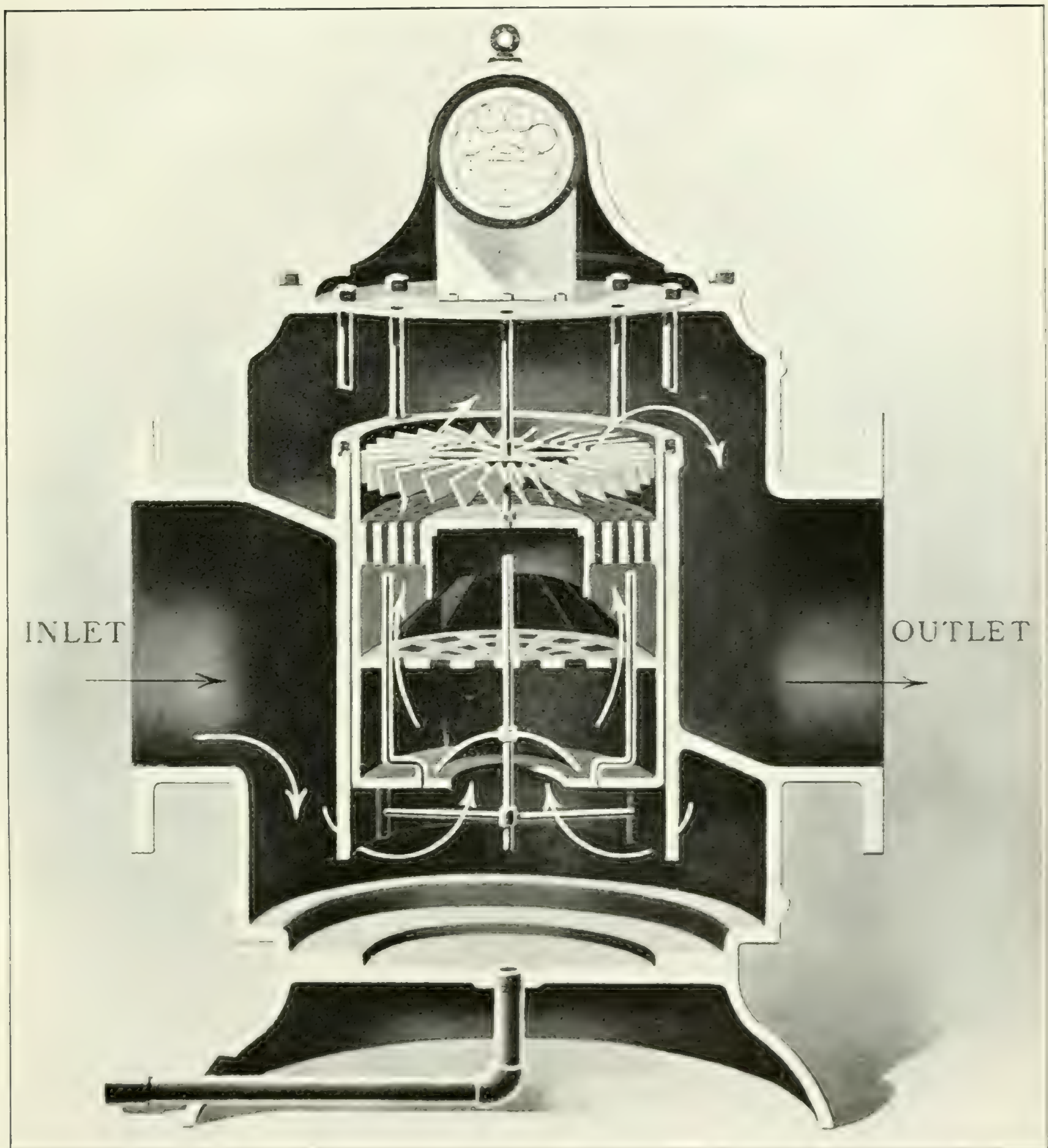


FIG. 10. Rotary meter

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i = difference of pressure on the two sides of the plates measured in inches of water.

P = mean pressure of air in pounds per square foot.

T = absolute temperature of the air in degrees Fahrenheit.

The difference in pressure between the two sides of the orifice plate was measured by means of an inclined gauge, reading to one hundredth of an inch of water.

The results of the calibration tests showed that, between the range of flow of 11,000 and 2,000 cubic feet of gas per hour, the meter reading was 13 per cent too high. The meter readings taken during the trial have been corrected by that amount in the final results.

Anti-pulsator. Between the meter and engine an anti-pulsator was interposed. This apparatus takes the place of a gas bag, and is used to correct the periodic change in the rate of flow, which is otherwise inevitable when the gas is being used by a gas engine.

Readings of Gas Meter. Readings of the gas meter and observations of the temperature and pressure of the gas passing through were made every half hour during the test.

Quality of the Gas. The gas was analysed every hour, and its calorific value determined every half hour for short period tests and every two hours for the trials of longer duration.

The gas samples for analyses were taken over a short space of time and analysed.

A continuous graphical record of the calorific power of the gas was kept by means of the Smith Recording Gas Calorimeter. This instrument is fully described in the Report on the Utilization of Peat Fuel.¹

Determination of Tar and Ammonia in the Offtake Gas.

Immediately after the gas left the producer, a sample was continuously withdrawn through a pipe introduced into the offtake with its open end turned to face the flow of the gas; the tar was extracted from the gas sample by means of a Brady tar filter, which consisted of a thimble of strong filter paper, through which the gas had to pass. This thimble was fixed tightly around a metal collar, through which the gas entered, and was surrounded by a metal jacket; this jacket was maintained at a temperature high enough to prevent condensation of water, by means of an electrically heated sleeve. After passing the filter, the gas was drawn through two wash bottles containing dilute sulphuric acid (one part acid to four parts water) to remove the ammonia, and finally passed through an ordinary gas meter. The measured volume of gas was then returned to the main stream from the producer by connecting up the meter to a tap at a point in the pipe near the Root's blower. At this point the suction is so much greater than at the offtake that the gas can be readily drawn through the filter, bottles, etc. The filter thimble was weighed, and the reading of the meter taken before and after each experiment, so that the amount of tar in the gas could be determined. The results obtained were calculated to give the weight of tar per 1,000 cubic feet of gas.

From time to time, as the volume of the liquid in the bottles grew too great, the wash bottles were rinsed out and the ammonia in the solution determined. Fresh acid was then put into the bottles for the next experiment. The increase in weight of the two wash bottles gave the quantity of water, plus ammonia, in the gas.

¹ Mines Branch Report No. 154.

The ammonia was determined as follows: The liquid from the bottles was made up to a definite volume; an aliquot part of this volume taken, and caustic soda added until the solution was strongly alkaline. The solution was distilled and the ammonia set free absorbed by a measured volume of decinormal sulphuric acid; the acid remaining unneutralized by ammonia was then titrated back with decinormal caustic soda. From this can be calculated the amount of ammonia in the aliquot part distilled, and so the total quantity of ammonia in the gas.

Determination of Tar in the Purified Gas.

This was carried out by means of a Sargent tar filter. The apparatus consisted of a metal case, containing a wire gauze, which served to support in a horizontal position a filter paper of 11 c.m. diameter; underneath the gauze was an electric lamp to heat the filter paper so that condensation of water could be prevented. The gas entered from above, passed through the filter paper, being thereby cleaned of tar, and left at the bottom of the apparatus. The gas was then measured by a meter, and burned. The filter paper was weighed before and after each experiment and, from the increase in weight and the volume of gas passed through, the amount of impurities per thousand cubic feet of the gas could be calculated.

The time of each experiment was not kept constant, but the filter papers were left until the tar collected in quantities, large enough to be weighed, this being readily shown by a slackening off in the rate of flow of gas through the meter.

Temperatures and Pressures. For the trials on the Körting producer the following readings were taken, at half-hourly intervals: The temperatures of the gas leaving the upper zone, and of the final gas leaving the producer, as shown by a Thwing electrical pyrometer; the pressures of the gas, as shown by water manometers at the base of the stand-pipe on the producer which conducts the gas from the upper to the lower zone, and at the exits of the producer, the coke scrubber, the tar filter, and the dry scrubber.

For trials on the Westinghouse producer readings were taken at half-hourly intervals, as follows:—

The temperature of the gas leaving the producer, as shown by a Bristol electrical pyrometer; the pressures of air entering the producer, and of the gas formed, shown by means of water manometers placed at the top and bottom air entrances to the producer, at the producer exit, scrubber exit, and blower exit.

The temperature of the saturated air blast was observed in the pipe leading from the vaporizer to the entrance to the lower zone.

Water supplied for cleaning and cooling the gas. All the water supplied for these purposes passed through a meter, and records of its readings were kept.

General record. A general record of events during the trial was kept. On this sheet the behaviour of the fuel, time of poking the producer, etc., were recorded.

Description of the Westinghouse Double Zone Bituminous Suction Gas Producer.

A Westinghouse gas producer plant, similar to that installed in the Fuel Testing Station, is shown in ideal section and perspective, in Figs. 11 and 12, respectively. The general path of the gas, after it leaves the producer, can be readily traced by referring to Fig. 11. The plant, in general, consists of a producer, gas washer, gas exhauster, pressure regulating gasometer, and gas mixing header.

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The gas formed in the two zones leaves the producer at its middle portion, and is conducted away through a large vertical pipe to the gas washer, etc.

The lower end of this pipe is submerged in a water seal, into which the waste water from the scrubber passes off with any impurity it may remove.

From the vertical pipe the gas is conducted to the bottom of the scrubber, through which it passes upwards. From the gas washer the gas passes into a large horizontal receiver, and then passes to a rotary positive exhaustor, driven by an electric motor. The blower maintains a suction on its producer side and a pressure on its opposite side.

For purposes of regulation, a by-pass connects the pressure and suction side of the system. In this by-pass are placed two valves, the one operated by hand, and the other operated by a small gas holder.

This pressure regulating gasometer is shown in Fig. 11, to the right of the blower. As the pressure in the gasometer rises, the bell rises, and through a system of levers opens the by-pass valve, thereby reducing the pressure. The pressure at which it is intended to operate the plant may be regulated by moving a sliding weight along the lever over the bell, thereby increasing or decreasing the force against which it has to move. A position of equilibrium will then be maintained by the bell rising until the gas pressure is balanced by the force on the bell. It will be observed that, as the bell rises, less of its height will be immersed in the water, thereby increasing the weight of the bell to be supported by the gas pressure, and so rendering a condition of stable equilibrium possible. If the demand for gas increases, the pressure in the gasometer will fall, which causes it to close the by-pass valve and thus deliver more gas to the source required, and reduce the quantity returning to the suction side of the exhaustor.

This combination of a gas receiver and by-pass assures the thorough mixing of the gas, which consequently decreases the variation in quality of gas, due to the charging of fuel and the poking of the producer.

The gas, after leaving the exhaustor, proceeds to the gas engine or other place, where it is desired to use it.

The Producer. By referring to Figures 11 and 13, which show vertical sections through the Westinghouse double zone producer, it will be seen that the producer consists of two zones, the upper one operating on the down-draft principle, while the lower operates on that of the up-draft.

There are three distinct air entrances. The air entrance on the right hand side of the cover of the producer admits air to the chamber formed by this cover. After being preheated in this chamber, the air passes down a vertical pipe to a hollow annular casting, which forms the vaporizer. The water, which is kept at a constant level in the vaporizer at about 2 inches from its top, is heated by the escaping gases from the fuel bed, which in their passage to the exit are compelled to come into contact with the walls of the vaporizer.

The air, after passing over the water of the vaporizer and becoming saturated with moisture, may proceed to either the upper or lower fuel bed, according to whether the valves in the two vertical pipes, leading to the air entrances of the upper and lower zones, are open or closed. In the event of the temperature in the vaporizer exceeding that due to the boiling point of water at atmospheric pressure, this air inlet cannot be employed since steam will pass to the atmosphere by the air inlet pipe, consequently, instead of saturated air proceeding to the combustion zone, steam alone will leave the vaporizer. No provision for preheating the air in this manner is made on the producer installed at the Fuel Testing Station, since the top cover is water, instead of air, cooled. The two other air entrances referred to are situated at the top and bottom left hand side of the producer. The air from these passes directly to the fuel bed, and the quantity desired is controlled by valves placed at the respective inlets. By regulating

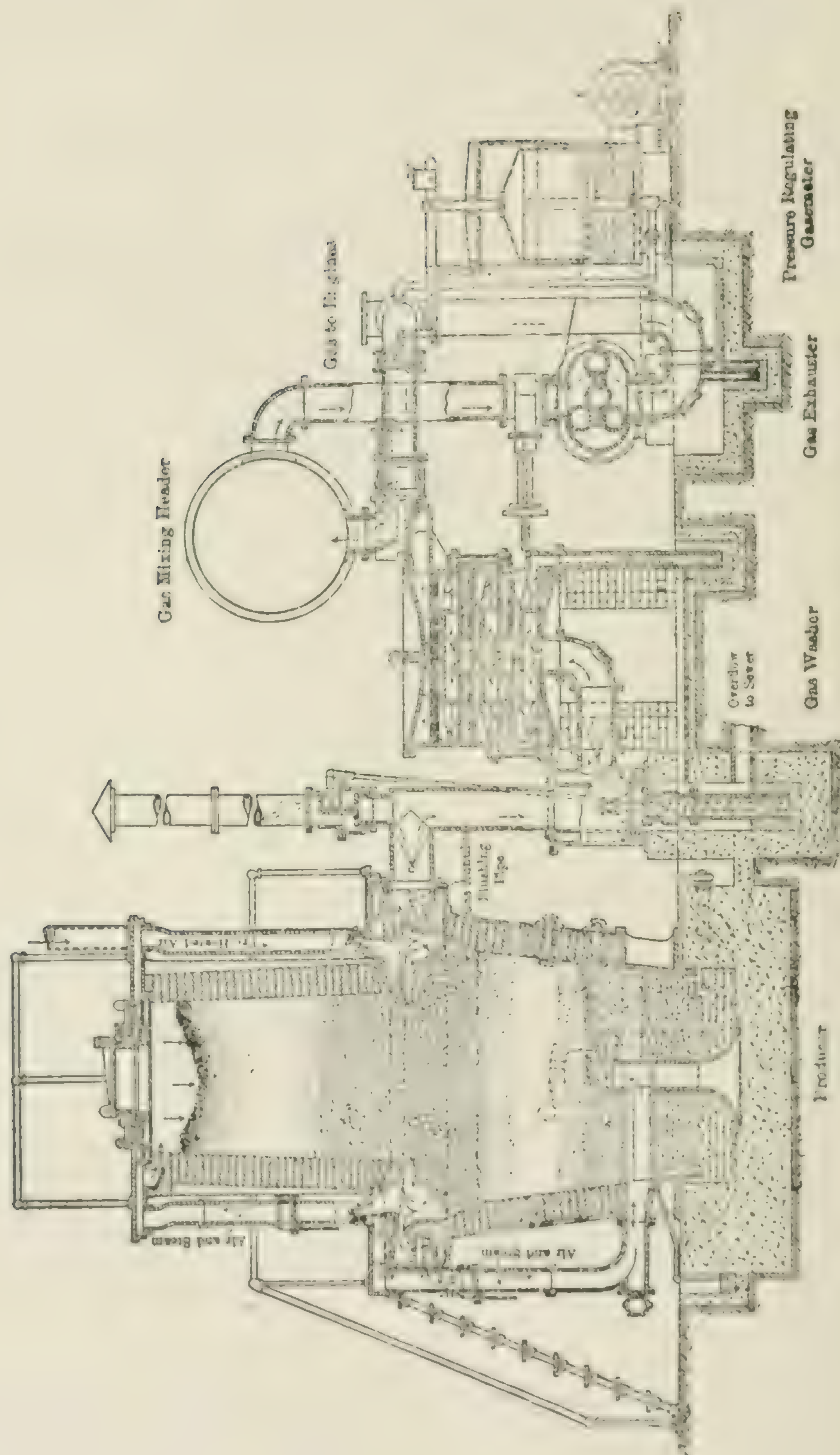


Fig. 11. Double zone gas producer (Westinghouse plant).

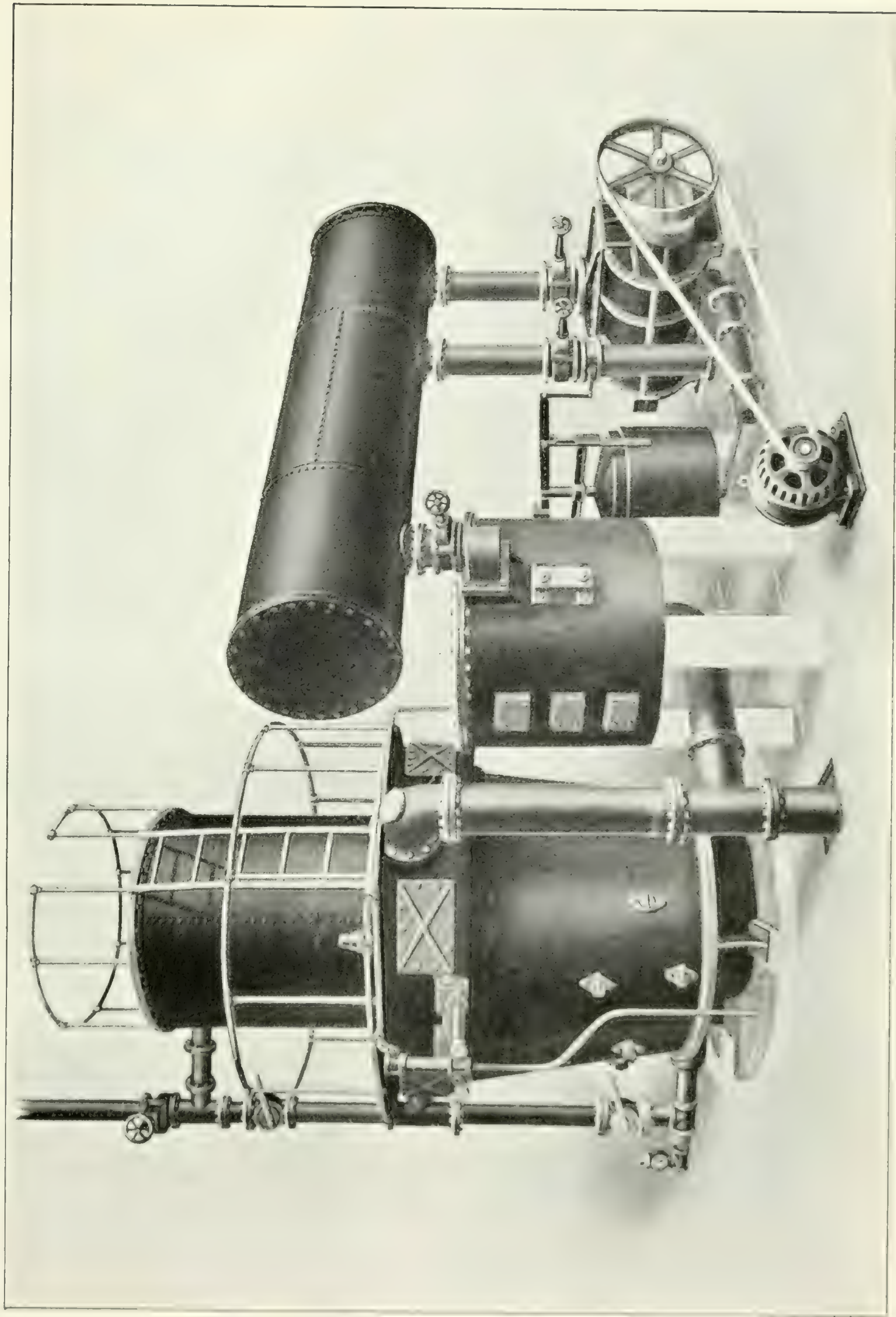


FIG. 12. Double zone gas producer plant (Westinghouse.)

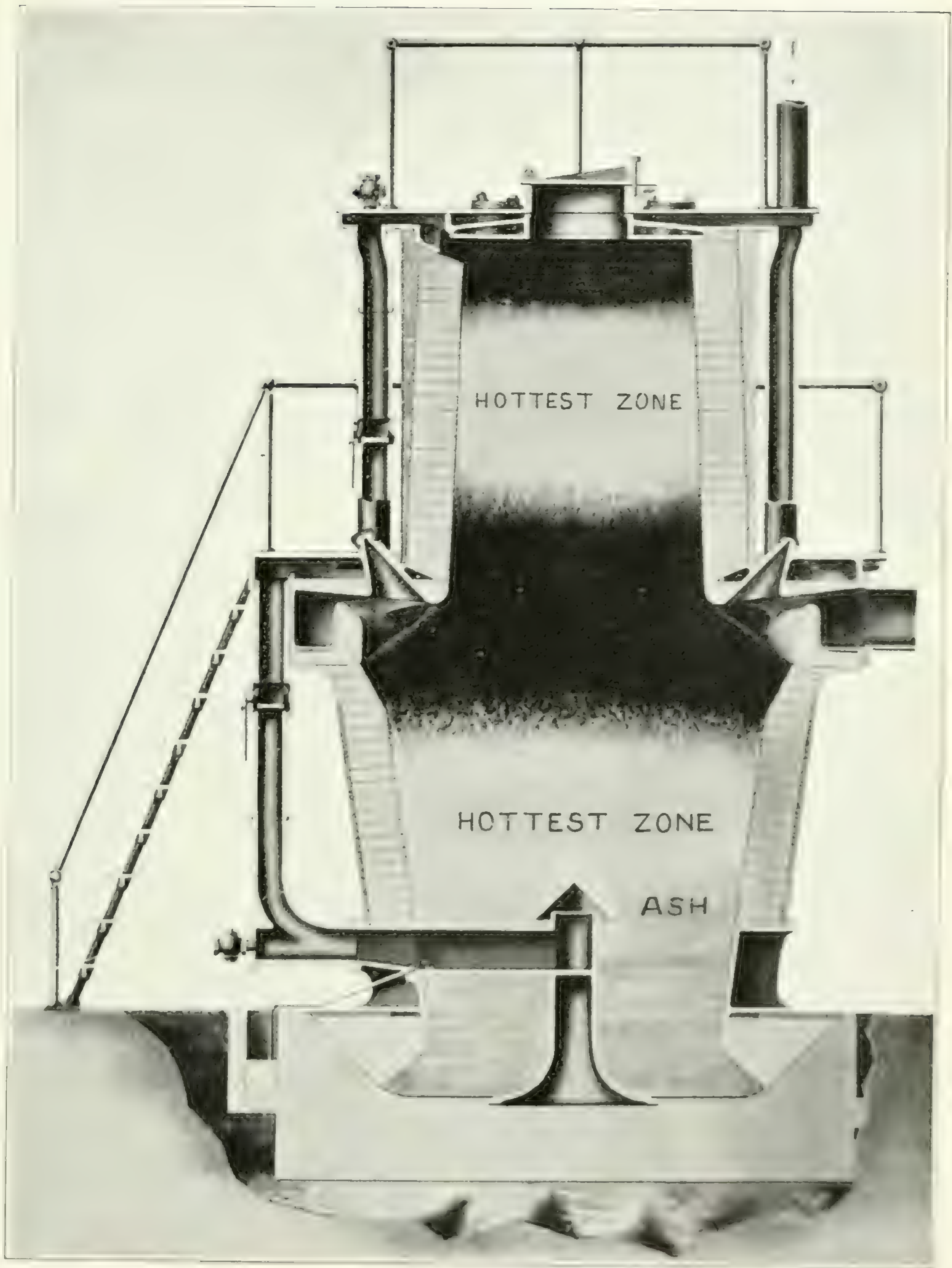


Fig. 13. Diagram of Westinghouse double zone producer—vertical section.



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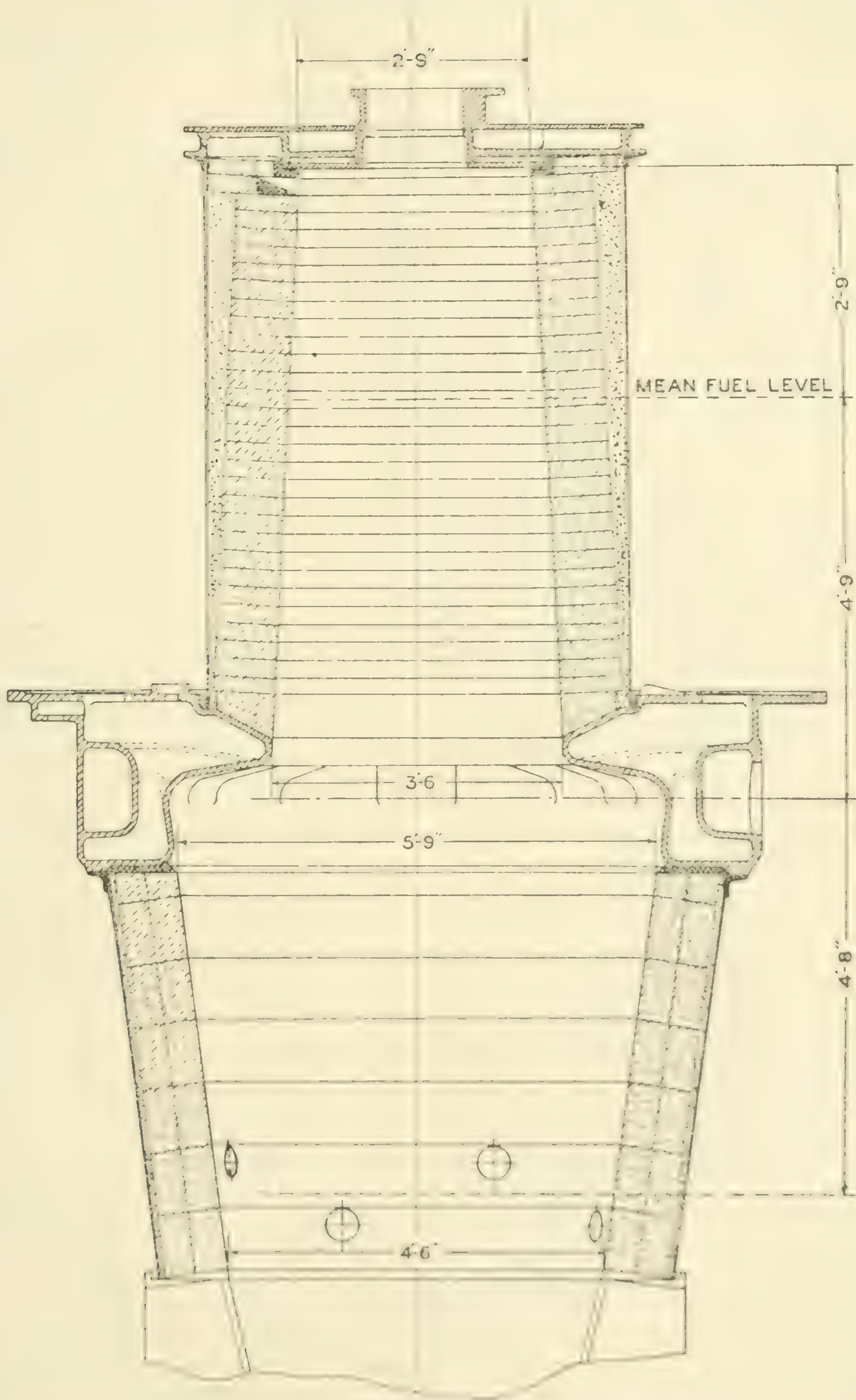


Fig. 14. Westinghouse producer : vertical section.

the ratio of the air received directly from the atmosphere to that passing over the vaporizer the quantity of steam entering the producer may be adjusted as required. The air admitted to the upper zone has free access to the full area of the upper fuel level; the air admitted to the lower zone passes through a central tuyere.

It is often found convenient to leave the fuel door, at the top of the producer, open for the admission of air when no steam is being used in the upper zone.

The producer is brick-lined round its sides, except for that portion occupied by the cast iron vaporizer. The upper zone is composed of a steel shell, between which and the brick lining is a space filled with sand. The lower zone of the producer consists of a steel shell lined up to the vaporizer with firebrick. The lower portion of this zone consists of a cast iron truncated cone, on which the producer proper rests. This portion is water sealed, as shown, and is supported by three cast iron columns, which rest on the concrete floor of the basin forming the water seal. The ashes are removed from the water seal through the space between the bottom of the producer shell and the floor of the water basin.

Pokeholes are provided at the top of the producer and above the vaporizer. The outside diameter of the upper section is less than the inside diameter of the lower section; this construction makes the lower half of the producer entirely accessible from the pokeholes in the vaporizer. Poking may also be carried on through the fuel entrance, and through two rows of staggered pokeholes, situated at about the ash level of the lower zone.

Design of the combustion zones. The form of the interior of the producer proper may be examined by reference to Figs. 14 and 15. Fig. 14 shows a section through the producer itself, and Fig. 15 shows diagrammatically the area of the fuel bed for varying depths of fuel. From a perusal of these figures it is apparent that the sectional area of the fuel space increases as the fuel descends through the upper zone, and decreases through the lower zone. The producer volume above the gas outlet is 40 cubic feet, while the volume, measured from midway between the lower pokeholes to the level of the centre line of the gas outlet, is 100 cubic feet.

The mean area of the upper fuel bed is about $8\frac{1}{2}$ square feet, while that of the lower is 20 square feet. The sectional area of the main upper fuel bed is increased by nearly 40 per cent for a change of 56 inches in depth, while the lower fuel bed decreases by nearly 40 per cent for a change in depth of 4 feet. The increasing section in the upper zone is to allow for the swelling of a coking coal, thereby causing a more uniform flow through the producer.

In the lower zone the fuel is being continually reduced in volume, owing to its combustion, and the reduction in diameter preserves a uniform flow on the same principle. Observation of the burning of the lignites tested showed that this fuel shrinks during its passage through the upper zone, leaving an air space between the fuel bed and producer walls. It would appear, therefore, that a decreasing sectional area in the upper zone rather than an increasing one would prove more suitable for fuels such as lignite or peat.

The total depth of incandescent fuel in the producer is affected by two independent variables, namely, the total rate of gasification and the ratio of the gasification in the upper zone to that taking place in the lower zone. If, e.g., the ratio of gasification in the two zones remains constant, then, as the total rate of gasification is increased, a greater depth of burning fuel will result, since a definite time is required for the reactions to take place. As the ratio of the gasification in the upper zone to that of the lower increases, for the same total rate of gasification, similar reasoning shows that the depth of the combustion zone in the upper bed will increase to a greater extent than the lower combustion zone depth decreases.

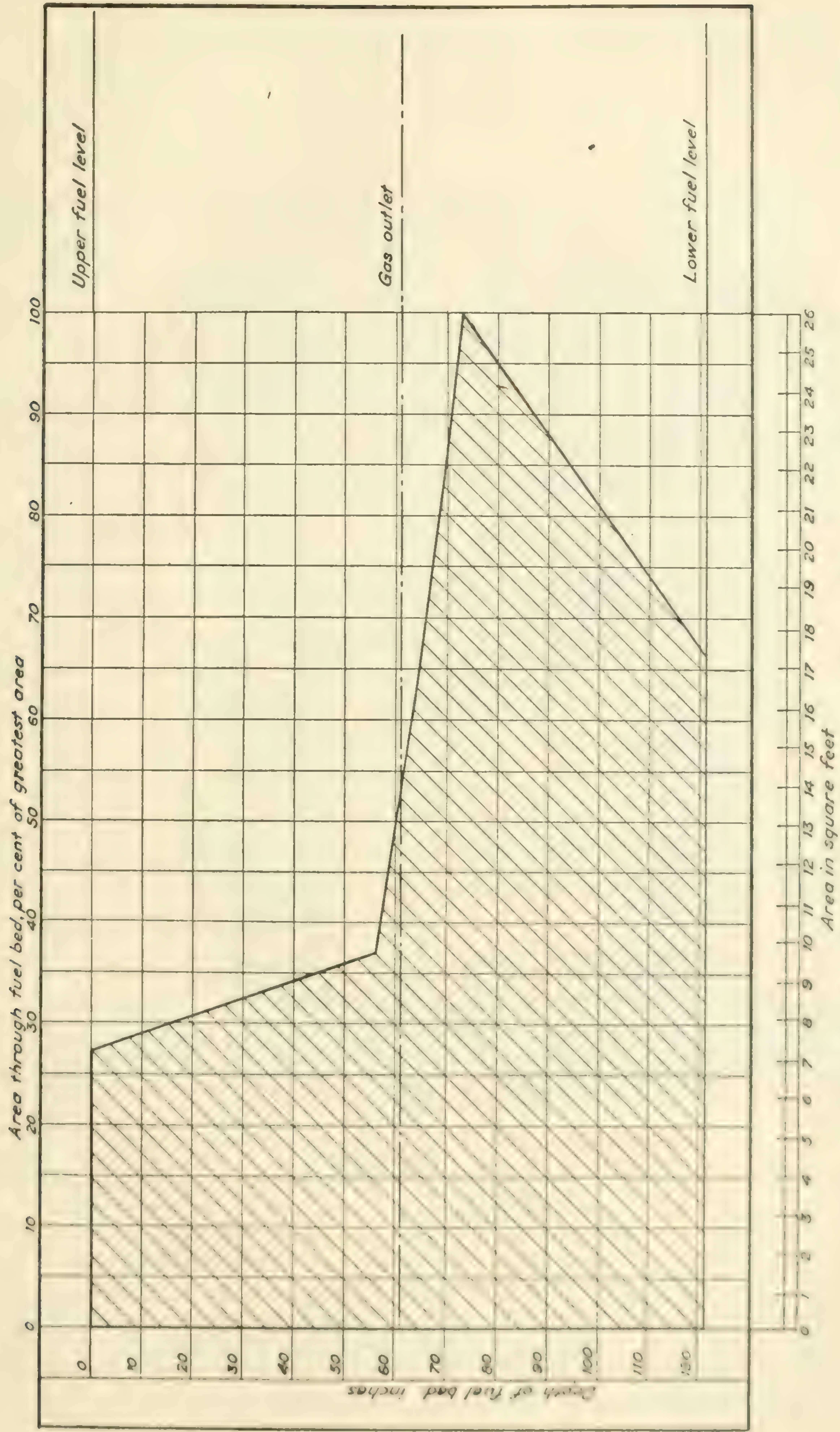


Fig. 15. Westinghouse producer : change of area with fuel depth.

In the operation of a double zone producer, it is difficult to ascertain the exact ratios of gasification in the two zones and the depths of incandescent fuel therein. The resistance to the passage of gas through the two zones is easily measured by means of water gauges; these differences of pressure however are affected by the condition of the fuel bed as well as by the velocity of flow of the gas, so that they only give an approximate idea of the relative operation of the two zones. In trial No. 39, the air supply to the lower zone was measured by observing the passage of air through an orifice in a plate, which showed that 53 lbs. of air passed to the lower zone per hour, the total air supply computed from the gas analyses and meter readings amounted to 317 lbs. per hour, which would show that about five sixths of the total air supply was taken by the upper zone: while the resistance of the upper fuel bed to the passage of gas was three times that of the lower. In the future, provision will be made for determining, directly, the air supply to both zones.

The position of the combustion zones in the fuel bed is likewise difficult to determine, the level of the top of the combustion zone in the top zone may of course be observed directly; but in the case of the lower zone an effort was made to maintain the position of the combustion zone at a level midway between the two lower rows of poke holes. How far these zones extend from these points is a matter for conjecture.

The high volatile and moisture contents of the lignites used in these tests rendered it necessary to gasify the greater portion of the fuel in the upper zone, using the lower zone to reduce such fuel as must inevitably be entrained with the ash leaving the upper zone.

While the area of the lower fuel bed is greater than is actually necessary from theoretical considerations for lignite fuels, a practical advantage of its increased diameter is that poking round the annulus is rendered easier, as has already been pointed out.

Purification of the Gas.

A baffle plate is placed in the gas offtake (see Fig. 11) which serves the purpose of removing the heavier particles of tar, dust, etc., which may be carried over by the gas from the producers.

The Washer.

This piece of apparatus is shown in Fig. 16. It is constructed of cast iron, and is divided by horizontal diaphragms into three compartments. Before entering this washer, the gas is cooled and cleaned to some extent by means of a series of water sprays, admitted at several points along the vertical pipe. After leaving the vertical pipe, the gas enters the washer beneath a cast iron bell, the lower edge of which is submerged in water. Extending outwards from the bell and beneath the water level in the compartment is a finely perforated metal plate. The gas forces its way under the edge of the bell and passes up through the perforated plate; by so doing the gas forms a series of small bubbles. These bubbles pass up through about one inch of water. The same operation is repeated for the two other sections of the washer. Water is introduced by means of spray nozzles as shown, and the overflow from the top compartment passes into the middle compartment through the connexion shown at the right just below the gas outlet. From the middle compartment the water overflows into the lower compartment through a similar connexion shown on the left. From the bottom compartment it passes out through the water sealed waste pipe shown at the right.

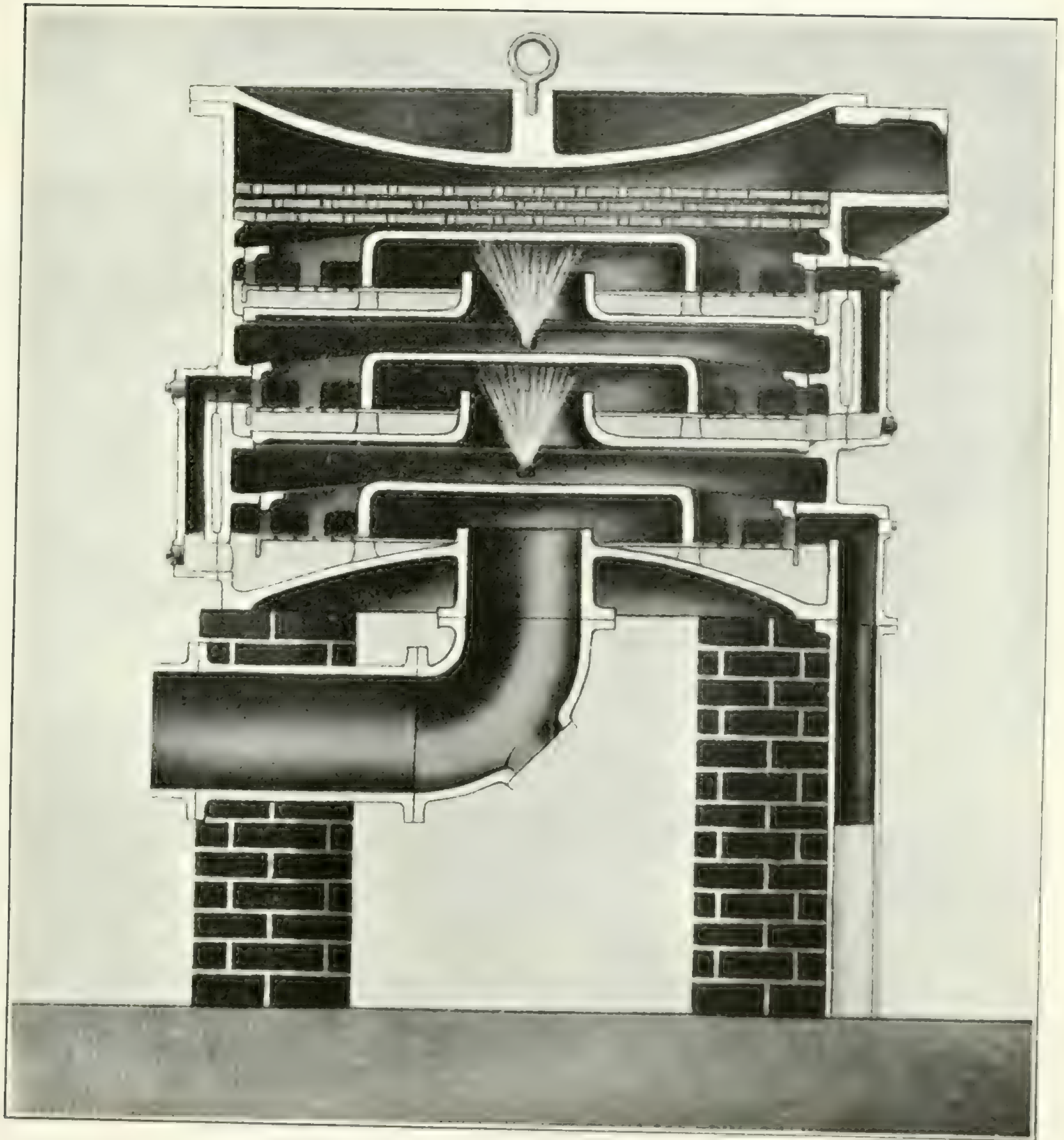


FIG. 16. Section through washer.

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Any desired depth of water may be maintained over the perforated plates, by means of adjustable weirs.

After leaving the washer, the gas enters a simple form of water separator which is not shown in the figure.

Tofield Trials Nos. 38, 39 and 44.

Three trials were carried out on this fuel, viz.; trials No. 38 and 39 in the Westinghouse, and trial No. 44 in the Körting producer. Trial No. 38 was of 51½ hours duration only, owing to the blocking of the gas outlet with dust; this was the only trouble which necessitated the shortening of any of the trials. Trial 39 was of 72 hours duration, the producer was operated at a slightly greater rate of gasification than No. 38. The efficiency of the latter trial was about five per cent greater than for 39, which is due to the greater quantity of hydrogen and hydro-carbons present in the gas as is shown by the gas analyses. Since the ratio of the resistance of the upper to the lower fuel bed during this trial was greater than in trial 39, it is likely that a greater portion of the total gas produced was formed in this zone than for trial 39.

The fuel clinkered to some extent in both tests, but this offered no real difficulty to the operation of the producer.

In both trials the resistance to the flow of gas through the upper zone was high while the temperatures of the final gas, as determined at the gas offtake, was approximately the same. The high resistance observed in the upper zone is due to the finely divided condition the fuel assumed after being subjected to heat.

Trial 44. An examination of the results of this test which was conducted in the Körting producer shows a marked difference to those of the two trials carried out with the same fuel in the Westinghouse producer. A comparison of the analyses of the gases produced in trial 44 with those of trials 38 and 39 will show that for the former the carbon monoxide has increased while the hydrogen and carbondioxide have decreased. This has effected an increase in the heating value of the gas. The increase in the carbon monoxide indicates that a higher temperature existed in the reaction zone; this is further borne out by the higher temperature of the escaping gases. No steam from an external source was admitted to the lower zone.

The quantity of tar per cubic foot of the final gas was much higher for this trial than for the two former trials (38 and 39), which shows that the Westinghouse producer delivers the cleaner gas. The lower efficiency may be principally accounted for, when the relative quantities of carbon charged and carbon in the gas are compared in the summary of results. These tables show that the former is much in excess of the latter, which indicates that the low efficiency is due to unconsumed fuel, i.e., carbon is contained in both the tar and the ash, which of course will not be accounted for in the purified gas.

Rosedale Coal—Trials Nos. 40 and 43.

Two trials were carried out on this fuel, trial No. 40 in the Westinghouse producer and No. 43 in the Körting.

Trial No. 40. During this trial the fuel gave very little trouble and produced a gas of high calorific value. This is due to the higher percentages of hydrogen and carbon monoxide contained in the gas. These, in fact, were higher during this trial than for any of the other trials carried out in the Westinghouse producer. The higher heating value was, however, accompanied by a greater

quantity of tar in the gas than in the other trials. The suction on the producer was lower than for any other trial with the Westinghouse producer in spite of the fact that the rate of gasification was high. This was due principally to the fact that the fuel did not pack so densely as the others, since its physical character was the least affected by heat; consequently it did not disintegrate into finely divided particles.

The fuel was very easily manipulated in the producer and the only unsatisfactory characteristic of the trial was the high percentage of tar in the gas. However, this in no way rendered the operation of the engine difficult.

Trial No. 43. During this trial Rosedale coal was gasified in the Körting producer. As in the previous trials conducted with this producer, the carbon monoxide content of the gas was higher than that of the gas produced from the same fuel when burned in the Westinghouse producer. The calorific value of the gas, however, is less for this trial than for trial No. 44, in which the Körting producer was used and the thermal efficiency of the producer is nearly twenty per cent lower than for trial No. 40. The total combustible charged amounted to 750 lbs., of which 140 lbs. was removed with the ash from the grates; this means that only four-fifths of the fuel was consumed, which accounts for the low producer efficiency. No difficulties whatever were encountered in the operation of the producer, and the engine ran well on the gas produced.

Gainford Coal—Trials Nos. 42 and 45.

Trial No. 45 was conducted with the Westinghouse producer, while for trial No. 42, the Körting producer was employed.

For trial No. 45, the efficiency and quantity of gas produced were very similar to that obtained with Rosedale coal. A comparison of the proximate analyses of the two fuels also shows great similarity, so analogous results might well be expected. There is, however, a marked difference in the cleanliness of the gas produced from the two fuels; the Gainford coal produced only 9.1 grams of tar per 1,000 cu. ft. of uncleaned gas, while for that of the Rosedale coal the tar content was 23.4 grams per 1,000 cu. ft. The resistance of the fuel beds to the passage of gas was low; but the ratio of the resistance of the upper zone to that of the lower zone was very high. This indicates that either the rate of gasification in the upper zone was high or that the resistance of the fuel in that zone was greater. It is probable that the incandescent fuel zone was deeper during this trial than in trial No. 40, on Rosedale coal, which would account for the lower tar content of the gas with this coal.

Trial No. 42, conducted with the Körting producer again showed that the gas produced contained a higher percentage of carbon monoxide and lower percentage of carbon dioxide and hydrogen than in that obtained from the same fuel when gasified in the Westinghouse producer. The calorific value of the gas for both trials was, however, the same. The tar present in the gas was very high, and although after cleaning it still contained 12.6 grams per 1,000 cubic feet, this did not interfere with the successful operation of the gas engine.

The quantity of refuse removed amounted to 514 lbs. (dry) of which 161 lbs. were ash and 353 lbs. combustible matter; the fuel charged contained 165 lbs. of ash and 1,469 lbs. combustible. The ratio of combustible consumed to combustible charged, or $(1,469 - 353)$ to 1,469, is therefore 0.76, and the efficiency of the producer based on combustible consumed is 45 per cent, which is very low.

The fuel clinkered badly during this trial, and therefore is not suitable for this type of producer without an arrangement being provided for admitting steam to the lower zone.

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Cardiff Colliery—Trial No. 46.

In trial No. 46, coal from the Cardiff colliery was gasified in the Westinghouse producer. This fuel required considerable attention, owing to its tendency to clinker and adhere to the lining of the producer. For this reason, it is doubtful whether the trial could have been prolonged 20 or 30 hours longer. In spite of its high moisture content (20 per cent) it is probable that the admission of steam to the upper fuel zone would have improved the behaviour of the coal, at least in so far as regards clinkering. The resistance of the upper fuel bed was high and the exit temperature of the gas was higher than in any of the other trials carried out with the Westinghouse producer except that of trial 47 (Twin City Coal). The analysis of the gas showed a fairly low percentage of carbon monoxide and high percentage of hydrogen. In fact the percentage of hydrogen was higher in only one other trial, viz.: trial 40. The content of tar per cubic foot was, however, exceptionally low.

The high efficiency of this fuel based on the coal as charged is discounted by the figures showing that the carbon leaving as gas, per hour, is greater than that charged. The ratio of carbon in gas to carbon charged is 1.07, and if the efficiency quoted (71.8 per cent) be reduced proportionately to this amount, an efficiency of about 67 per cent will result.

Twin City Coal—Trial No. 47.

Only one trial (No. 47) was run with this fuel. As with the Cardiff coal, considerable trouble was experienced with clinkering. These clinkers formed rings near the top and round the vaporizer, which proved very difficult to break up.

The gas analysis of this fuel differs considerably from those of the other trials on the Westinghouse producer. The hydrogen and carbon dioxide are both low, as is also the ammonia carried in the gas. An examination of the fuel bed resistances indicates that the proportion of fuel burnt in the lower zone during this trial was greater than in any of the other trials in this type of producer. From a comparison of this trial with the other trials carried out with the Westinghouse producer it will be seen that the ammonia, carbon dioxide and hydrogen contents of the gas were the lowest, while the temperature of the gas leaving at the offtake was the highest. From this it is obvious that too high a temperature prevailed in the producer and that better gas would have been obtained by admitting more steam. It will be observed that the gasification of the fuel was carried on at a greater rate than in the other tests, to which may be partly attributed the high temperature. The gas during this test was clean.

The thermal efficiency of the producer was low, which may be attributed to the insufficient supply of steam to the lower zone, or to too small a gasification in the upper zone.

Practical Value of the Gas Produced.

The gas produced from the several lignites tested was used in the gas engine in order to ascertain its suitability for the production of power. The gas engine employed for this purpose was of only 60 B.H.P., while the capacity of the producer was considerably greater. Only a portion of the gas generated could, therefore, be used in this manner.

In every case the engine operated satisfactorily, although in certain cases the calorific value of the gas was rather low. The principal fact to be considered is the cleanliness of the gas. The quantity of tar and solid matter after leaving the wet scrubber was of so small amount that no trouble was experienced from

the deposition of tar on the valves, piston rings and cylinder. As a matter of fact, the engine could be run for an indefinite period before the necessity for cleaning the various moving parts, exposed to the flow of gas, would arise. For power purposes, therefore, the gas generated in this type of producer from those lignites tested, is eminently suitable.

The value of the gas for steam raising or for the generation of heat for industrial purposes was not investigated. It is, however, quite probable that no difficulties would arise were the gas to be utilized for such purposes.

It will be noted that, in the summary of results, values have been given showing the consumption of fuel per B.H.P. hour. These values are all based on the performance of an engine, the overall efficiency of which is 25.45 per cent, i.e. which has a heat consumption of 10,000 B.T.U. per hour per B.H.P. developed. This heat consumption is representative of the average performance of a well designed gas engine, when it is operated in the vicinity of its rated load.

Conclusions.

The results of the trials show that all the lignites tested were eminently suited for the production of gas when burned in the gas producer. The operation of the producer in no case presented serious difficulties although some trouble, in certain of the trials, was experienced from clinkering. The majority of the lignites, however, were remarkably free from components giving rise to the formation of clinkers. Steam admitted into the upper zone would very likely reduce the tendency to clinker, but when no provision for the introduction of steam is provided, careful poking will have to be resorted to when the lignites utilized produce bad clinkers. Throughout the trials which were of long duration, the gas was remarkably uniform in chemical composition and free from tar or solid matter such as dust.

No trouble whatever was experienced from the burning of the gas in a gas engine, and lignites may therefore be said to be eminently suited for the production of power in this manner.

The labour required for the operation of a producer and gas engine of the capacity employed during the tests is very small. One operator when properly trained would prove sufficient to handle such a plant per shift.

The quantity of cooling water required to clean and cool the gas is not excessive, and on account of the small amount of the by-products carried away with the water leaving the scrubber, no trouble should be experienced in sufficiently cleaning the water for use over and over, in case the supply of water is a serious matter.

In certain of the lignites, the nitrogen content is sufficiently high to make its recovery as ammonia or ammonium sulphate, under favourable circumstances, profitable.

It has been shown that a slacked lignite behaves exceedingly well when burned in the gas producer and that the cheaper grades can therefore be utilized for the production of gas and power.

Summary of Results of Gas Producer Trials.

Note: "W" signifies the Westinghouse producer, and "K" the Korting producer.

Name of Fuel.		Tofield.			Rosedale		Gainford		Cardiff colliery	Twin City
No. of Trial		38	39	44	40	43	42	45		
Producer		W	W	K	W	K	K	W	W	W
Date of trial	1913	June 19-21	July 2-5	Aug. 9.	July 14-17	Aug. 7	July 31	Aug. 25-28	Sept. 2-5	Sept. 9-12
Duration of trial	Hours	51.5	72	12	72	12	12	72	72	72
PROXIMATE ANALYSIS OF FUEL (as charged).										
Fixed carbon	'Per cent'	36.7	36.7	37.3	43.4	43.7	43.8	43.8	40.4	41.3
Volatile matter	"	29.8	29.8	30.2	33.6	33.8	30.8	30.8	31.6	33.3
Ash	"	8.5	8.5	7.5	6.5	7.2	8.4	7.7	8.0	7.3
Moisture	"	25.0	25.0	25.0	16.5	15.3	17.0	17.7	20.0	18.1
ULTIMATE ANALYSIS OF FUEL (as charged).										
Carbon	'Per cent'	50.4	50.4	50.9	57.3	57.7	53.8	53.8	52.1	54.1
Hydrogen	"	6.6	6.6	6.7	5.8	5.7	5.0	5.1	6.4	5.9
Oxygen	"	33.3	33.3	33.7	28.7	27.7	30.6	31.2	32.2	31.2
Nitrogen	"	0.9	0.9	0.9	1.3	1.3	1.6	1.6	1.1	1.1
Sulphur	"	0.3	0.3	0.3	0.4	0.4	0.6	0.6	0.2	0.4
Ash	"	8.5	8.5	7.5	6.5	7.2	8.4	7.7	8.0	7.3
CALORIFIC VALUES OF FUEL BY CALORIMETER.										
Calorific value of fuel as charged per lb. 'B.T.U.'		7,990	7,990	8,080	9,650	9,720	9,040	9,040	8,770	9,160
" " dry fuel per lb., "		10,650	10,650	10,770	11,560	11,470	10,890	10,980	10,960	11,180
" " combustible per lb., "		12,020	12,020	11,970	12,530	12,540	12,120	12,120	12,180	12,280
AVAILABLE PRESSURES, TEMPERATURES, ETC. °F.										
Temperature of saturated air to lower zone °F.		205	200	620	442	720	642	208	209	207
" " gas leaving producer, °F.		427	408	176	340	340	255	390	461	519
" " upper zone, °F.										
Resistance of upper fuel bed lower " " inches of water.		14.4	19.0	0.2	4.0	0.1	0.1	6.6	14.0	14.1
		2.5	6.1	1.4	0.7	0.7	1.7	0.5	3.6	7.2
		21.7	25.9	6.5	10.8	5.7	7.5	13.3	21.1	20.5
TOTAL QUANTITIES.										
Fuel charged during trial.	lbs.	6,215	8,761	1,350	10,884	968	1,969	10,686	9,320	10,641
Dry fuel charged during trial.	"	4,661	6,571	1,013	9,088	820	1,634	8,795	7,456	8,715
Combustible in fuel charged during trial.	"	4,133	5,826	911	8,381	750	1,469	7,972	6,710	7,938
Carbon in fuel charged during trial.	"	3,132	4,415	687	6,236	559	1,059	5,749	4,856	5,757
Gas heated at 600° F. and 14.7 lbs. per sq. in.) supplied by producer during trial.	cu. ft.	366,680	482,360	41,308	580,530	40,011	52,270	548,010	600,640	666,790
QUALITY OF GAS.										
Analysis by volume, 'Per cent'.										
Carbon dioxide.		12.5	12.5	9.6	10.4	9.1	8.7	11.2	12.8	9.4
Carbon monoxide.		10.6	12.2	18.3	17.3	18.6	19.3	16.6	13.5	16.5
Hydrogen.		14.6	14.1	12.6	16.7	12.4	12.9	15.0	15.3	11.0
Methane.		1.8	1.7	2.2	2.1	1.7	2.2	2.4	1.4	0.8
Ethylenes.		0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.1
Oxygen.		2.4	1.7	1.0	0.5	0.9	1.2	0.7	1.0	1.5
Nitrogen.		58.1	57.8	56.2	53.0	57.2	55.6	54.0	56.0	60.7
Calorific value from analysis, gross, B.T.U. per cu. ft.		27.0	28.0	33.2	36.1	32.8	34.5	34.1	30.2	28.4
Cal. value from analysis, gross, B.T.U. per cu. ft., net.		100	103	123	131	117	126	126	106	97
Cal. value from Boy's calorimeter (gross) B.T.U. per cu. ft.		90	94	114	120	109	117	116	97	91
Tar is undecanted gas.		101	94	127	127	118	125	125	108	93
Decanted gas.		10.6	12.9	56.3	23.4	....	35.0	9.1	4.5	5.3
Nitrogen in undecanted gas.		1.0	0.6	14.9	7.9	....	12.6	1.5	0.1	0.2
		11.0	14.6	27.9	23.3	....	12.6	21.2	9.4	1.5

III.

CHEMICAL LABORATORY OF THE FUEL TESTING STATION.

Edgar Stansfield.

The year 1913 has marked a great advance in the provision of facilities for laboratory work, and the amount of work done. Six rooms were set aside for new chemical laboratories in the extensions made to the Fuel Testing Station; these rooms have been equipped to serve respectively as:—balance room and office, gas analysis and calorimetry laboratory, general laboratory, furnace room, sample preparation room, and store room. The general equipment of benches, tables, etc., was practically completed by the end of March, and regular work was commenced in April, although the ventilating system was not completed until November.

The new rooms have given great satisfaction, and allow a higher standard of work to be maintained than in the past. The increased space available allows the special pieces of apparatus, most in use, to be permanently set up in a convenient location. Producer gas is now piped up to the laboratory, and, by means of a small sampling pump, distributed to the gas calorimeter, tar filter, sampling bottles, etc. This is a great convenience as it obviates the necessity of the chemist leaving the laboratory to obtain his samples, or to carry out tests in the producer room.

Apart from smaller apparatus and general supplies, the equipment of the laboratory has been augmented during the past year as follows: Braun Chipmunk crusher; Four-jar, Abbé ball mill; heavy load precision balance; Sartorius balance; Keller button balance; pulp balance; Case gas muffle furnace; Pfungts autoclave; mercury still; experimental gas meter; three coal calorimeters; together with the following oil testing appliances; refractometer; chromometer; three viscosimeters; and three flash point apparatus. Some twenty volumes have been added to the laboratory library, and arrangements were made whereby three German, one French, five English, and four American journals bearing on applied chemistry are regularly received.

The laboratory staff was permanently increased during the year by the appointment of Dr. F. E. Carter, on July 1, 1914. Mr. W. B. Meldrum acted as special temporary assistant, from June to September; and Messrs. M. F. Connor, and H. A. Leverin, of the Chemical Division of the Mines Branch have rendered assistance on several special occasions.

The work of the laboratory may be roughly classified into four sections:—

- (I) Chemical work required during the producer or boiler trials carried out from time to time in the plant.
- (II) Analyses of fuel, gas, and of oil samples taken in connexion with the above tests; or from samples taken in the field by officers of the Department of Mines, or submitted by outside parties.
- (III) Special investigations, such as the standardization of methods of air drying fuels for analysis, coking of lignites, distillation of tars, etc., etc.
- (IV) Analyses of ores etc., in connexion with the work of the Ore Concentrating Division carried out in the same building.

Every endeavour has been made to maintain a high standard in the work of the laboratory. Determinations, with very few exceptions, are made in duplicate when this is possible; and a system has been introduced whereby all calculations are checked by a second member of the staff, before a report is issued.

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The regular work of the laboratory got into arrears during the months the laboratory was closed for alterations to the building; and this leeway has not yet been entirely made up. The samples submitted for analysis, during the year, have been far greater than in any previous year; and there is every indication that the increase will continue. The present staff is no longer large enough to cope with the chemical tests demanded in even the first two sections of the above classification of work; and many special investigations, which are both important and urgent, are necessarily being held up. One extra chemist is urgently needed for the fuel testing work; but two men could be kept fully employed to great advantage. In addition to the above, a chemist is required to give his attention to the samples from the Ore Concentrating Division.

The chemical determinations made in the laboratory during the year include the following: (1) in connexion with the ten producer trials carried out on a large scale during the months of June to September; (2) 9 full analyses of lignite coal were made; (3) 28 ash samples were analysed; (4) 276 complete gas analyses made; (5) 306 determinations of the calorific value of gas; (6) 64 determinations of tar in gas; and (7) 22 determinations of ammonia in gas. Other samples submitted for analysis include 26 mine lignite samples; 8 samples of peat taken in connexion with a peat drying process investigated by Mr. B. F. Haanel in New York; and 26 samples of peat from Mr. Anrep's field investigations in Quebec. Ten samples of coal from Graham island, B.C., have been analysed for the Geological Survey; 9 samples of anthracite coal for the Department of Militia and Defence; and 2 samples of coal, and one sample of a fire box deposit have been examined for the Board of Railway Commissioners. Other parties have submitted 2 coal samples, 3 lignite samples, 17 peat samples, 2 oil samples, 1 sample of briquetted sawdust, and 5 samples of natural gas. Eight determinations of the calorific value of city gas have been made, and 70 iron ore samples have been analysed for the Ore Concentrating Division.

IV.

INVESTIGATION OF PEAT BOGS.

Aleph von Anrep.

A survey of the peat bogs in the Provinces of Ontario and Prince Edward Island was carried on during the season of 1913, in order to investigate and determine the extent, depth, and different qualities of the peat contained in the various bogs.

Early in June the writer left Ottawa, with Mr. E. P. Sawyer as a temporary assistant, to perform the field work.

The following statement briefly summarizes the results of the season's investigation.

Ontario Peat Bogs.

The peat bogs examined in Ontario during June, part of August, September, October, November, and part of December, 1913, were:—

- (1) Richmond peat bog situated $2\frac{1}{2}$ miles south of Richmond village in Goulburn and Marlborough townships, Carleton county. The total area covered by this bog is approximately 5,500 acres, with a depth varying from 3 to 7 feet. The Canadian Northern railway traverses the western end of the bog.
- (2) Luther peat bog, situated 7 miles west of Grand Valley station on the Canadian Pacific railway, in West and East Luther townships, Dufferin and Wellington counties. The total area covered by this bog is approximately 4,900 acres. The depth of the bog varies from 3 to 16 feet. The peat is well humified, and possesses considerable cohesive properties.
- (3) Amaranth peat bog, situated about 4 miles west from Crombie station on the Canadian Pacific railway, in Amaranth township, Dufferin county. The total area covered by this bog is approximately 500 acres. The depth of the bog varies from 4 to 7 feet.
- (4) Durham peat bog, situated 5 miles northeast from Durham in the township of Glenelg, county of Grey. The total area covered by this bog is approximately 40 acres with an average depth of about 4 to 7 feet.
- (5) Eastnor peat bog, situated about 20 miles north of Wiarton in the township of Eastnor, county of Bruce. This bog is comparatively large, but being situated a considerable distance from shipping facilities and market, I considered it practically valueless, hence no investigation was made.
- (6) Cargill peat bog is situated 6 miles west of Cargill station, Grand Trunk railway, in Greenock township, Bruce county. The total area covered by this bog is approximately 6,600 acres with a depth varying from 2 to 4 feet.
- (7) Westover peat bog situated about 4 miles south of Schaw station, on the Canadian Pacific railway in Beverly township, Wentworth county. The area of the bog which is investigated, is approximately 1400 acres. The depth of the bog varies from 3 to 5 feet.

The bogs near Dundas, Dunnville, and Port Colborne are nothing else than flooded areas and land with insufficient drainage.

During the early part of September, preliminary investigations were made of the bogs situated in the southern part of the Rainy River district, north of the Rainy River, Pine Wood, and Emo stations, on the Canadian Northern railway.

- (8) Sunderland peat bog situated about 1 mile north of Sunderland, in the township of Brock, county of Ontario. The total area covered by this bog is approximately 580 acres, with a depth varying from 3 to 7 feet. The peat is very well humified.
- (9) Marsh Hill peat bog, situated about 1 mile east of Uxbridge, immediately east of Blackwater junction and Sunderland, and $1\frac{1}{2}$ miles south from Cannington on the Grand Trunk railway, in Uxbridge, Reach, and Brock townships, Ontario county. The total area covered by this bog is approximately 5,100 acres, with a depth varying from 4 to 27 feet. The peat in this bog is very well humified, and possesses considerable cohesive properties.
- (10) Manilla peat bog, situated 2 miles west of Manilla station on the Grand Trunk railway, in Mariposa township, Victoria county. The total area covered by this bog is approximately 745 acres, with a depth varying from 4 to 10 feet.
- (11) Stoco peat bog, situated $1\frac{1}{2}$ miles south of Stoco station, on the Bay of Quinte railway, in Hungerford township, Hastings county. The total area covered by this bog is approximately 1,027 acres, with a depth varying from 3 to 16 feet. The peat is well humified, and possesses considerable high cohesive properties.
- (12) Tweed peat bog, situated about 1 mile south of Tweed, on the Bay of Quinte railway, in the Hungerford township, Hastings county. The total area of this bog is approximately 50 acres, with a depth varying from 2 to 8 feet.
- (13) Buller peat bog, situated 1 mile south of Buller station on the Canadian Pacific railway, in Hungerford and Huntingdon townships, in Hastings county. The total area covered by this bog is approximately 100 acres, with a depth varying from 2 to 7 feet.
- (14) Clareview peat bog. This bog is situated about $2\frac{1}{2}$ miles northwest from Erinsville station, on the Bay of Quinte railway. The total area covered by this bog is approximately 328 acres, with a depth varying from 1 foot to 4 feet.

The approximate total area investigated in the Province of Ontario, during the season of 1913, was 26,870 acres. Some of the bogs are well situated as regards shipping facilities and markets, being adjacent to railways, and near to large towns.

Prince Edward Island.

During the progress of the above mentioned investigations, I also investigated, during the month of July, a small peat fuel bog near Charlottetown, and a peat litter bog near Conway, Prince Edward Island.

- (15) Mermaid peat fuel bog, situated 5 miles northeast from Charlottetown, and about 2 miles from Mount Herbert station, on the Intercolonial railway, in the township of Bedford, Queens county. The total area covered by this bog is approximately 186 acres, varying in depth from 3 to 10 feet.
- (16) The Black Banks peat litter bog is situated about 7 miles north of Conway station, on the Intercolonial railway, and about 5 miles south of Alberton, by water, across the Cascumpeque bay. The total area covered by this bog is approximately 884 acres, with a depth varying from 3 to 20 feet. The bog contains a very fine peat litter, which is fairly free from humus, from the surface to the bottom.

The approximate area investigated in the Province of Prince Edward Island during the month of July, 1913, was 1,070 acres.

SESSIONAL PAPER No. 26a

During the earlier part of August, I attended the Convention of the International Geological Congress, in Toronto; and later in the month attended the American Peat Society's meeting in Montreal; in connexion with which I had an opportunity of visiting the peat plants at Alfred, Ontario, and at Farnham, Quebec, where I witnessed these plants in operation.

Detailed descriptions, determinations, and maps, will be published in a separate report.

SESSIONAL PAPER No. 26a

REPORT OF THE MINERAL RESOURCES AND STATISTICS
DIVISION.*John McLeish.*

Chief of Division.

The annual collection of statistics of mining and metallurgical production, and the compilation and publication of reports thereon, as in previous years, chiefly engaged the attention of this Division, during 1913. The usual number of statistical reports, listed below, were prepared, and numerous enquiries answered and memoranda written regarding the mining industries and mineral resources of the country.

In addition to the regular work of the Division, considerable time was spent—in co-operation with other members of the Mines Branch staff—in the preparation of a special report on the "Economic Minerals and Mining Industries of Canada." This report received a wide distribution at the Canadian Section of the International Exhibition, at Ghent, Belgium, and at the International Geological Congress, held at Toronto in August. At the request of the Secretary of the International Geological Congress, the writer undertook the organization and conduct of a "Mining and Geological Information Bureau" at the Congress headquarters in Toronto University, Toronto; in which he had the co-operation of several members of the staff of both branches of the Department of Mines. Following the session of the Congress in Toronto he accompanied Excursion C-1 to Victoria and return, undertaking the duties of Secretary for the excursion. Mr. Cartwright assisted in the work undertaken in connexion with the Congress, subsequently accompanying Excursion C-2 through a portion of its itinerary, and then visited several mining districts in British Columbia in the interests of the Division.

The collection of statistics of mineral production for 1912, begun at the first of the year, was sufficiently far advanced in the latter part of February, to enable me to prepare the usual preliminary report entitled "Preliminary Report on the Mineral Production of Canada, during the Calendar Year 1912," which was published and distributed on March 4, 1913, and was included as an appendix to the Summary Report of the Mines Branch, for 1912.

In compliance with a request from Mr. J. L. Hutchison, Canadian Exhibition Commissioner, the preparation of a descriptive pamphlet on Canada's Mining Industries and Resources for distribution at the International Exhibition in Ghent, Belgium, was undertaken. A somewhat similar publication had been published by the Department for use at the Paris Exposition, in 1900, and had been several times revised for distribution at subsequent World's Fairs. With the assistance of Messrs. C. T. Cartwright, L. H. Cole, H. Fréchette, H. S. de Schmid, and Dr. A. W. G. Wilson, a short, comprehensive report on the Economic Minerals and Mining Industries of Canada was completed and published on June 4. Practically every mineral of economic importance, and all known important occurrences were briefly referred to. In addition, the report contained statistics of mineral production for 1912, and short separate reviews of the mineral occurrences in each province, with references to the mining laws in force, and the names and addresses of the several Provincial and Dominion Departments from whom further information respecting mineral resources or mining regulations might be obtained. The report was immediately translated into French, for distribution at the Canadian Section of the International Exhibition at

Ghent, and a large number were distributed amongst the members of the International Geological Congress, at the Toronto meeting.

The publication, as advance chapters, of separate parts of the final report on mineral production was again continued, and in pursuance of the plan, five separate chapters were completed on the dates shown in the following list.

In addition to the reports published, a number of lists of mine and quarry operators were prepared, or revised, and published during the year. These lists were printed primarily to assist the Division in keeping its office lists corrected and complete, but a limited number are available for distribution to those who may desire them. Lists of operators not separately published will be found in the Annual Report on the Mineral Production during 1912.

The following reports and lists were published during the year being sent to press on the dates indicated:—

Reports.

Preliminary Report on the Mineral Production of Canada during the calendar year 1912—February 27.

Economic Minerals and Mining Industries of Canada, 1913—June 4.

A General Summary of the Mineral Production of Canada, during the calendar year 1912—July 9.

The Production of Iron and Steel in Canada, during the calendar year 1912—July 25.

The Production of Copper, Gold, Lead, Nickel, Silver, Zinc and other Metals in Canada during the calendar year 1912—August 21.

The Production of Cement, Lime, Clay Products, Stone and other Structural Materials in Canada during the Calendar year 1912—September 20.

The Production of Coal and Coke in Canada during the calendar year 1912—September 29.

Annual Report on the Mineral Production of Canada, during the calendar year 1912—October 16.

Lists of Mine and Quarry Operators.

List of Manufacturers of Clay Products in Canada, including a list of the manufacturers of sand lime brick—October

List of Lime Burners in Canada—October.

List of Stone Quarry Operators in Canada—October.

List of Coal Mine Operators in Canada—March.

List of Metal Mines and Smelter Operators in Canada—December, 1913.

The correspondence of the Division during the year comprised about 8,693 letters and circulars sent out, and 3,317 received. Seven statistical reports prepared by the Division were distributed during the year, comprising about 17,000 copies. The amount of work involved in the compilation of statistics of production, imports and exports, the preparation and revision of lists of operators, the writing and checking of reports, and other routine work of the Division, has increased very rapidly during the past three years, and additional clerical assistance is now imperative.

Much time is taken up in the preparation of information for correspondents and others respecting the mining industries and mineral resources of the country, an endeavour being made in all cases, so far as the records and reports of the Department will permit, to furnish enquirers with the information asked, or advise them where it may be obtained.

SESSIONAL PAPER No. 26a

Mr. C. T. Cartwright, as in the previous year, undertook the compilation of the statistics of metalliferous production, and prepared the special parts of the Annual Report dealing with the production of copper, gold, lead, nickel, zinc, and miscellaneous metals. During August, September, and October, he visited various mining camps in British Columbia and reports as follows:—

“On August 4, the writer left for Toronto, and was, until the 14th, engaged under your direction, in the temporary office opened by the Department at the International Geological Congress sessions.

At the close of the meeting he accompanied Excursion C-2 as far as Nelson, taking advantage of the opportunity given to visit several of the coal mines of the Crowsnest Pass district. After leaving the party on August 20, a rapid study of the condition of mining in the Province was made for the information of the Division of Mineral Resources and Statistics, some six weeks being so occupied before returning to Ottawa. Among the localities studied were Ainsworth, Kaslo, Trout Lake, Sandon, New Denver, Silverton and Slocan City; Nelson, Trail and Rossland in West Kootenay; Phoenix, Greenwood, Princeton, and Kamloops in Yale; Vancouver, Victoria, and Prince Rupert on the coast; and Hazelton in the Omineca.

While most of the information so gathered will appear in the reports of the Division, or be used in connexion with the work of compilation, the following points of specific interest may be noted. At Ainsworth the development of the previous year had been continued, placing the Number One, Highland, Maestro, and Silver Hoard mines on a shipping basis, and some other properties were being re-opened.

Near Sandon the new deep level tunnel at the Slocan Star mine had reached the vein, and the Payne and Noble Five mines were also cross-cutting at depth. In the Similkameen the British Columbia Copper Company were doing a considerable amount of development work at their Princess camp properties. Despite the financial depression, a number of mining companies on the coast had started work during the year, a few reaching the shipping stage. The new 2000 ton copper smelter of the Granby Consolidated Mining, Smelting, and Power Co., at Anyox on Observatory inlet, was nearing completion and expected to start operations early in the New Year; while near Hazelton the neighbouring silver-lead and copper camps were developing, the former already having two mines—the American Bay, and the Silver Standard—making fair sized shipments.

The salt deposits at Kwinitsa, near Prince Rupert, were attracting some attention.

The continuance of the strike at the coal mines near Nanaimo had a marked effect on the coal trade of the coast, and was especially noticeable in hastening the installation on so many of the coastwise operating steamships, of oil burning apparatus. For the past few years the use of oil has been growing rapidly owing to the cheapness and efficiency of the fuel, and now, not only the locomotives on the Pacific Division of the Canadian Pacific railway, but also that Company's coastal steamships and those of the Grand Trunk Pacific railway, are using oil.

The writer desires to express his appreciation of the courtesy shown him by the Provincial officials, and all with whom he came in contact.”

INTERNATIONAL GEOLOGICAL CONGRESS.

At the request of the Secretary of the Twelfth International Geological Congress, an office was opened at headquarters in Toronto University, Toronto, during the session of the Congress, from August 7 to 14, for the purpose of furnishing information to members of the Congress relating to the mining industry and mineral resources, and the geological investigations and studies that have

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been made in Canada, and for the distribution of reports and maps relating thereto. Representatives of both the Mines Branch and Geological Survey, as well as several of the Provincial Bureaus of Mines, were in attendance. Complete sets of the publications of the Mines Branch, and the Geological Survey, were available for reference, and a large number of economic reports and maps of the Department were distributed. A comprehensive set of maps of Canada and of the several Provinces, typical geological maps, and maps of mining districts were mounted and hung for reference. Other Departments of the Dominion Government, including several branches of the Department of the Interior, and the Commission of Conservation, supplied reports, maps, and copies of mining regulations.

The co-operation of each of the Provincial Bureaus of Mines was also obtained, and copies of their reports, maps, and mining laws were furnished for reference and distribution. The current issues of the more important technical, mining, and geological journals were solicited, and cheerfully furnished; while a number of the larger mining companies kindly supplied copies of their annual reports.

The opportunity offered to study and obtain official records of the natural resources of Canada, was highly appreciated, and taken full advantage of by members of the Congress.

Mineral Production during 1913.

A Preliminary Report on the Mineral Production of Canada during 1913 is now being prepared, and will, as usual, be published on or about March 4, 1914. It will be found included as an appendix to this Annual Summary report.

DRAUGHTING DIVISION.

H. E. Baine.

Chief of Division.

The staff of this division consists of a chief officer, two map compilers, two assistant draughtsmen, and one mechanical draughtsman.

The work assigned to this division consists, principally, in the preparation of magnetometric maps, and the drawing of various diagrams, sketches, etc., to illustrate reports, and in the preparing of drawings in connexion with the work of the Fuel Testing Station and the Ore Dressing Laboratory.

During the year a very much needed modern blue print machine has been installed, and has given every satisfaction.

The following is a list of maps, diagrams, and miscellaneous drawings prepared during the year—the name of the officer for whom they were prepared appears in the margin.

E. Lindeman.

205. Magnetometric map—Moose Mountain iron-bearing district, Sudbury district, Ontario,—Deposits Nos. 1, 2, 3, 4, 5, 6, and 7. Scale 200 feet to 1 inch.
- 205A. Geological map—Moose Mountain iron-bearing district, Sudbury district, Ontario,—Deposits Nos. 1, 2, 3, 4, 5, 6, and 7. Scale 400 feet to 1 inch.
206. Magnetometric map—Moose Mountain iron-bearing district, Sudbury district, Ontario,—Northern part of Deposit No. 2. Scale 200 feet to 1 inch.
207. Magnetometric map—Moose Mountain iron-bearing district, Sudbury district, Ontario,—Deposits Nos. 8, 9, and 9A. Scale 200 feet to 1 inch.
208. Magnetometric map—Moose Mountain iron-bearing district, Sudbury district, Ontario,—Deposit No. 10. Scale 200 feet to 1 inch.
- 208A. Magnetometric map—Moose Mountain iron-bearing district, Sudbury district, Ontario,—Eastern portion of Deposit No. 11. Scale, 200 feet to 1 inch.
- 208B. Magnetometric map—Moose Mountain iron-bearing district, Sudbury district, Ontario,—Eastern portion of Deposit No. 11. Scale, 200 feet to 1 inch.
- 208C. General Geological map—Moose Mountain iron-bearing district, Sudbury district, Ontario. Scale, 800 feet to 1 inch.
249. Magnetometric map—Caldwell and Campbell mines, Calabogie district, Renfrew county, Ontario. Scale, 200 feet to 1 inch.
250. Magnetometric map—Black Bay or Williams mine, Calabogie district, Renfrew county, Ontario. Scale, 200 feet to 1 inch.
251. Magnetometric map—Bluff Point iron mine, Calabogie district, Renfrew county, Ontario. Scale, 200 feet to 1 inch.
252. Magnetometric map—Culhane mine, Calabogie district, Renfrew county, Ontario. Scale, 200 feet to 1 inch.
253. Magnetometric map—Martel or Wilson mine, Calabogie district, Renfrew county, Ontario. Scale, 200 feet to 1 inch.
261. Magnetometric map—Northeast Arm iron range, Lot 339, E. T. W., Lake Timagami, Nipissing district, Ontario. Scale, 200 feet to 1 inch.

A. Anrep.

Map showing peat bogs investigated in Province of Quebec.

Cacouna Peat Bog, Quebec.

La Parc Peat Bog, Quebec.

St. Denis Peat Bog, Quebec.

Rivière du Loup Peat Bog, Quebec.

Small Tea Field, " " "

Large Tea Field " " "

Rivière Ouelle, " " "

St. Hyacinthe " " "

Lanorie " " "

Moose Mountain " " "

Profile of Rivière du Loup Peat Bog, Quebec.

Profile of Rivière Ouelle Peat Bog, Quebec.

Plan of Peat Shed and Tracks.

Plan and Sections of Excavating Machine.

B. F. Haanel.

3 large drawings of gas plants.

22 drawings, charts, etc.

T. A. MacLean.

Map—Dawson mining district.

Map—Mining districts in Yukon.

4 diagrams and 35 drawings.

J. G. S. Hudson.

Map—Sydney coal field, Nova Scotia.

16 coloured plates of sections of coal seams.

John McLeish.

Mineral map of Canada: to accompany report on Economic Minerals and Mining Industries of Canada.

A. W. G. Wilson.

Map—Eastern Cape Breton as a possible smelting centre.

Eastern Townships as a possible smelting centre.

Relative position of Copper Smelters in British Columbia.

Location of Copper Smelters in Canada.

39 large drawings for plates and cuts.

SESSIONAL PAPER No. 26a

REPORT COVERING THE OPERATIONS OF THE DOMINION OF
CANADA ASSAY OFFICE, VANCOUVER, B.C., DURING THE
YEAR ENDING DECEMBER 31, 1913.

SIR,

I have the honour to submit herewith report covering the operations of the Dominion of Canada Assay Office, Vancouver, B.C., for the calendar year ending December 31, 1913, accompanied by statements showing Assayers' and Melters' supplies on hand.

Changes in Staff.

H. Freeman appointed assayer, March 1, 1913.

F. W. Taylor appointed clerk, May 1, 1913, transferred to Immigration Department, June 3, 1913.

T. B. Younger appointed clerk, July 3, 1913, vice F. W. Taylor.

The abolition of the assaying and stamping charge of $\frac{1}{8}$ of one per cent on the gross value of the gold and silver contained in deposits, authorized by Order-in-Council dated January 16, 1913, has resulted in a considerable increase of business, 111,479.95 troy ounces gold bullion having been deposited at this office during the year just ended, as compared with 59,068.83 troy ounces during the calendar year 1912, an increase of 52,411.12 troy ounces.

Detailed Statement.

There were 783 deposits of gold bullion, requiring 926 melts and 926 assays (quadruplicate check assays being made in each instance) including the assembling and remelting of the individual deposits after purchase into bags weighing about 1,000 troy ounces and the assaying of same. The aggregate weight of the deposits before melting was 111,479.95 troy ounces and after melting 109,920.49 troy ounces, showing a loss in melting of 1.3989 per cent. The loss in weight by assaying was 12.75 troy ounces (base and parted silver), the average fineness of the resulting bullion, viz., 109,907.74 troy ounces, being .633 gold and .241 silver. The net value of the gold and silver contained in deposits was \$1,448,625.37.

The gold bullion received came from the following sources, viz:—

Source.	Number of deposits.	Weight.		Net value.
		Before melting.	After melting.	
		OZS.	OZS.	
British Columbia.....	655	95,871.51	94,411.08	\$1,196,775.34
Yukon Territory.....	117	15,324.65	15,236.50	247,188.95
Alaska.....	11	283.79	272.91	4,661.08
	783	111,479.95	109,920.49	\$1,448,625.37

Weight before melting..... 111,479.95 troy ounces.

Weight after melting..... 109,920.49 " "

Loss by melting..... 1,559.46 " "

Loss percentage by melting..... 1.3989%

NOTE:—28.75 ounces gold bullion, value \$408.79 (recovered from slag, sweepings, old furnaces, old crucibles, etc. reported as residue on hand December 31, 1912, were turned over to the Chief Assayer on March 3, 1913, to be made into proof gold and proof silver for assaying purposes.

SESSIONAL PAPER No. 26a

Residues on Hand, December 31, 1913.

Recovered from slag, sweepings, old furnaces, old crucibles, etc.—53.95 ounces gold
 bullion, value..... \$613.83
 100 lbs. slag.
 16 empty acid bottles.

Miscellaneous Receipts.

Draft No. 317, in favour of Deputy Minister of Mines—(a payment for melting 5.43
 ozs. jeweller's sweepings.....\$1.50
 Draft No. 317, in favour of Deputy Minister of Mines—(a payment for melting 2.94
 ozs. jeweller's sweepings.....\$1.50 \$ 3.00
 Draft No. 3, in favour of Deputy Minister of Mines—(a payment for melting
 28.72 ozs. silver bullion)..... 1.50
 Draft No. 29, in favour of Deputy Minister of Mines—(a payment for treating
 26.38 lbs.slag)..... 13.10
 \$ 17.60

The following shows the business done by the Assay Office during the past
 five years, viz.:—

Calendar year.	Number of deposits.	Weight (troy ounces)	Net value.
1909	573	48,478.60	\$ 789,267.94
1910	490	46,064.31	746,101.92
1911	442	39,784.70	647,416.38
1912	527	59,068.83	974,077.14
1913	783	111,479.95	1,448,625.37

I have the honour to be, Sir,

Your obedient servant,

(Signed) G. MIDDLETON,

Manager.

4 GEORGE V., A. 1914

DECEMBER 31st, 1913

G. MIDDLETON, Esq.,
Manager, Dominion of Canada Assay Office,
Vancouver, B.C.

Sir,

I beg to inform you that we have the following Assayers' supplies on hand,
viz.:—

Silver nitrate crystals.....	1 oz.
Calcic chloride.....	$\frac{3}{4}$ lb.
Lead foil, C.P.....	116 lbs.
" granulated, C.P.....	2 $\frac{1}{2}$ "
Zinc, mossy, C.P.....	1 lb.
Litharge.....	5 lbs.
Copper wire.....	1 spool.
Argols.....	4 lbs.
Nitric acid, C.P.....	13 Winchesters.
Hydrochloric acid, C.P.....	1 Winchester
Sulphuric acid, C.P.....	$\frac{1}{2}$ "
Ammonia.....	1 $\frac{1}{4}$ Winchesters.
Small clay crucibles.....	36 only.
Scorifiers, 4".....	2
" 2 $\frac{1}{2}$ ".....	90
Spare muffles.....	2
" " doors.....	8
" " supports.....	21
" " back stops.....	16
" " plugs.....	12
Bone ash.....	1 lb.
Fireclay.....	20 lbs.
Cupels.....	11,300
Gold cornets.....	11.67 ozs.
" proof.....	23.25 "
Silver.....	213.50 "

Your obedient servant

(Signed) J. B. FARQUHAR,
Chief Assayer.

December 31, 1913.

G. MIDDLETON, Esq.,
Manager, Dominion of Canada Assay Office,
Vancouver, B.C.

Sir,

I beg to inform you that we have the following supplies on hand in the
Melting Department, viz.:—

3 sets of inings, with supports and covers complete, for No 2 furnace.	
4 " " " " " " " " " " " "	4 $\frac{1}{2}$ "
5 " " " " " " " " " " " "	7 "
2 graphite crucibles, No. 6.	
46 " " " " " "	16.
4 " " " " " "	30
4 " " " " " "	40.
40 " " " marked $\text{o}^{\text{o}}_{\text{o}}$	
4 crucible covers, No. 14.	
8 " " " " " "	30.
3 graphite stirrers.	
11 lbs. pot. nitrate.	
90 lbs. carb. soda.	
25 lbs. borax glass.	

Your obedient servant,

(Signed) D. ROBINSON,
Chief Meller.

SESSIONAL PAPER No. 26a

ACCOUNTANT'S STATEMENT, 1912-13.

The following is a statement of the difference in value of assays between Seattle Assay Office and Dominion of Canada Assay Office between April 1, 1912, and March 31, 1913.

Paid for bullion at Dominion of Canada Assay Office, Vancouver.....	\$1,065,995.10
Received for bars from United States Assay Office, Seattle.....	1,066,626.53
Difference in favour of Dominion of Canada Assay Office.....	631.43

Statement of Deposits of Gold and Earnings.

Deposits of Gold..... \$1,066,626.53

Earnings:—

Melting 119.55 ozs. silver for Jacoby Bros.....	5.00
Special Assay for J. E. Wilkinson.....	2.50
Melting .25 ozs. bullion for J. E. Wilkinson.....	1.00
Treating 27 lbs. slag for John Hopp.....	12.00
Melting 8.37 ozs. jeweller's sweepings for Shortt, Duncan and Hill..	3.00

23.50

Difference between amounts paid and received for bullion..... 631.43

\$654.93

The following is a statement of appropriation, receipts and expenditure of the Dominion of Canada Assay Office for the year ending March 31, 1913, and shows the unexpended balance to be \$2,716.79.

	Appropriation.	Expenditure.
Appropriation, 1912-13.....	\$17,000.00	
Receipts per the foregoing statement.....	23.50	
Difference between amounts paid and received for bullion.....	631.43	
Fuel.....		350.60
Power and Light.....		184.89
Postage and Telegrams.....		105.28
Telephone.....		78.00
Express Charges.....		866.52
Assayer's Supplies.....		1,329.13
Printing and Stationery.....		228.76
Premium on Bonds.....		575.02
Contingencies.....		239.65
Electric burglar alarm service.....		300.00
Wages:—		
G. Middleton.....		2 650 00
J. B. Farquhar.....		1,328.84
H. Freeman.....		856.69
D. Robinson.....		1,575.00
A. Kaye.....		1,800.00
G. N. Ford.....		1,500.00
G. B. Palmer.....		81.25
R. Allison.....		888.51
Balance unexpended and lapsed.....		2,716.79
	<u>\$17,654.93</u>	<u>\$17,654.93</u>

ACCOUNTANT'S STATEMENT, 1913-14.

The following is a statement of the difference in value of assays between Seattle Assay Office and Dominion of Canada Assay Office between April 1, 1913, and March 31, 1914.

Paid for bullion at Dominion of Canada Assay Office, Vancouver.....	\$1,456,468.70
Received for bars from United States Assay Office, Seattle.....	1,457,653.11
Difference in favour of Dominion of Canada Assay Office.....	1,184.41

Statement of Deposits of Gold and Earnings.

Deposits of gold.....	\$1,457,653.11
Earnings:—	
Melting 28.72 ozs. bullion for J. Greer.....	\$ 1.50
Treating 26.38 lbs. slag for John Hopp.....	13.10
Value of 24 empty jars sold B.C. Assay and Chemical Supply Co.....	2.88
Value of residue sold United States Assay Office.....	872.51
	889.99
Difference between amounts paid and received for bullion.....	1,184.41
	\$2,074.40

The following is a statement of the appropriation, receipts and expenditure of the Dominion of Canada Assay Office for the year ending March 31, 1914, and shows the unexpended balance to be \$12,131.17.

	Appropriation.	Expenditure.
Appropriation, 1913-1914.....	\$27,000.00	
Receipts per the foregoing statement.....	889.99	
Difference between amounts paid and received for bullion.....	1,184.41	
Fuel.....		403.30
Power and light.....		197.12
Postage and telegrams		93.19
Telephone.....		78.00
Express charges		1,203.11
Assayer's supplies		747.33
Printing and stationery		190.47
Premium on bonds.....		600.00
Contingencies.....		137.16
Electric burglar alarm service.....		300.00
Wage:—		
G. Middleton.....		2,650.00
J. B. Farquhar.....		1,900.00
H. Freeman.....		1,500.00
D. Robinson.....		1,575.00
A. Kaye.....		1,800.00
G. N. Ford.....		1,500.00
R. Allison.....		975.00
F. W. Taylor.....		200.00
T. B. Younger.....		893.55
Balance unexpended and lapsed.....		12,131.17
	\$29,074.40	\$29,074.40

SESSIONAL PAPER No. 26a

LIST OF REPORTS, BULLETINS, ETC., PUBLISHED DURING
1913.*S. Groves.*

Editor Department of Mines.

83. An investigation of the Coals of Canada with reference to their economic qualities: as conducted at McGill University, Montreal, under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R.J. Durley, Ma.E., and others.
Vol. IV.—Appendix II: Boiler tests and diagrams, by R. J. Durley. Published February 20, 1913.
Vol. V.—Appendix III: Producer tests and diagrams, by R. J. Durley. Published May 15, 1913.
Vol. VI.—Appendix IV: Coking tests, by Edgar Stansfield, M.Sc. and J. B. Porter.
Appendix V: Chemical tests, by Edgar Stansfield. Published April 3, 1913.
145. Magnetic Iron Sands of Natashkwan, Saguenay county, Que., by G. C. Mackenzie, B.Sc. Published June 6, 1913.
151. Bulletin No. 8: Investigation of the Peat Bogs and Peat Industry of Canada, 1910-11, by A. v. Anrep. Published March 31, 1913.
167. Pyrites in Canada: Its Occurrence, Exploitation, Dressing, and Uses, by A. W. G. Wilson, Ph.D. Published March 3, 1913.
170. The Nickel Industry: with Special Reference to the Sudbury region, by A. P. Coleman, Ph.D. Published July 29, 1913.
184. Magnetite Occurrences along Central Ontario railway, by E. Lindeman, M.E. Published Oct. 7, 1913.
199. The Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and other Metals of Canada, during the calendar year 1911, by C. T. Cartwright, B.Sc. Published January 23, 1913.
201. Annual Report of the Mineral Production of Canada during the calendar year 1911, by J. McLeish. Published June 4, 1913.
216. Preliminary Report on the Mineral Production of Canada, during the calendar year 1912, by J. McLeish. Published March 4, 1913.
224. Annual Summary Report of the Mines Branch, 1912. Published November 11, 1913.
227. Sections of the Sydney Coal Fields, Cape Breton, by J. G. S. Hudson. Published July 14, 1913.
229. Reprint of Summary Report on Petroleum and Natural Gas Resources of Canada, by F. G. Clapp. Published October 4, 1913.
230. Economic Minerals and Mining Industries of Canada, by Mines Branch staff. Published July 22, 1913.
238. General Summary of the Mineral Production in Canada during the calendar year 1912, by J. McLeish. Published October 16, 1913.
247. Production of Iron and Steel in Canada during the calendar year 1912, by J. McLeish. Published December 5, 1913.
256. Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and other Metals in Canada during the calendar year 1912, by C. T. Cartwright. Published Nov. 6, 1913.
258. Production of Coal and Coke in Canada during the calendar year 1912, by John McLeish. Published December 27, 1913.

FRENCH TRANSLATIONS.

M. Sauvalle.

155. French translation: The Utilization of Peat Fuel for the Production of Power, being a record of experiments conducted at the Fuel Testing Station, Ottawa, 1910-11, by B. F. Haanel, B.Sc. Published November 24, 1913.
156. French translation: The Tungsten Ores of Canada, by T. L. Walker. Published June 26, 1913.
196. French translation: Bulletin No. 4: Investigation of the Peat Bogs, and the Peat Industry of Canada, during the season 1909-1910 (Second Edition), by A. v. Anrep. Published June 25, 1913.

- 197. French translation: Molybdenum Ores of Canada, by T. L. Walker, M.A., Ph.D. Published April 18, 1913.
- 198. French translation: Peat and Lignite, their Manufacture and Uses in Europe, by E. Nystrom, M.E. Published May 19, 1913.
- 202. French translation: Graphite: Its Properties, Occurrence, Refining, and Uses, by F. Cirkel, M.E. Published April 16, 1913.
- 226. French translation: Chrome Iron Ore Deposits of the Eastern Townships: Monograph on, by Fritz Cirkel, M.E. Published October 17, 1913.
- 231. French translation: Economic Minerals and Mining Industries of Canada, by Mines Branch staff. Published August 5, 1913.
- 233. French translation: Gypsum deposits of the Maritime Provinces, by W. F. Jennison, M.E. Published December 30, 1913.

SESSIONAL PAPER No. 26a

ACCOUNTANT'S STATEMENT MINES BRANCH.

Statement of Appropriations and Expenditures 1912-13.¹

	Grant.	Expenditure.	Grant not used.
Investigation of ore deposits, economic minerals, peat bogs, determination of fuel values, coals and peat of Canada, including wages of mechanics and labourers, additional machinery; investigation of ore dressing, including machinery and equipment of laboratory; collection of information regarding minerals and metallurgical industries and operations.....	75,000.00	73,345.53	1,654.47
Printing, books, stationery, chemical laboratories' expenses and apparatus, office contingencies, additional assistance.....	55,000.00	42,113.76	12,886.24
Investigation of metallurgical problems of economic importance.....	9,300.00	9,297.37	2.63
Investigation of quartz and copper deposits in the Yukon	9,200.00	8,430.59	769.41
For apparatus and equipment, salaries of inspectors, chemist, machinist, clerical assistance, and travelling expenses in connexion with the investigations of the manufacture and storage of explosives in Canada.....	5,000.00	284.85	4,715.15
Zinc investigations per Bill No. 182.....	41,937.94	7,671.17	34,266.77
Compassionate allowance to Mrs. E. A. Sjostedt, whose husband was employed by the Mines Branch to report on concentrating and electric smelting processes in Norway and Sweden, and who met his death by the foundering of the Titanic.....	500.00	500.00	
	<u>195,937.94</u>	<u>141,643.27</u>	<u>54,294.67</u>
DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C.			
Maintenance of Assay Office, Vancouver, B.C.....	17,000.00	14,283.21	2,716.79
	(Signed) JNO. MARSHALL.		
	Accountant.		

12 May, 1913.

¹The fiscal year ends March 31.

STATEMENT OF APPROPRIATION AND EXPENDITURE BY MINES
BRANCH FOR YEAR ENDING MARCH 31, 1913.

	Appropriation.	Expenditure.
Amounts voted by Parliament.....	\$257,987.94	
Receipts for assays and analyses.....	570.15	
Civil List Salaries.....		\$60,184.08
Concentrating Laboratory.....		35,987.19
Publication of Reports.....		31,319.05
Fuel Testing Plant, Ottawa.....		11,974.94
Investigation of Iron Ore Deposits.....		9,344.54
Metallurgical Investigations.....		9,297.37
Quartz Investigations.....		8,430.59
Zinc Investigations.....		7,671.17
Printing, stationery, books, mapping material.....		4,927.72
Investigation of Peat and Coal.....		4,374.53
Monograph on Petroleum and Natural Gas.....		4,000.00
Mining and Metallurgical Investigations.....		2,146.09
Miscellaneous.....		2,142.86
Investigation re Gas Producers.....		1,469.51
Laboratory.....		1,349.03
Wages, outside service.....		1,348.89
Monograph on Building Stones.....		1,061.35
Investigation of Copper Deposits.....		891.40
Investigation re Manufacturer's Raw Materials.....		844.07
Investigation of Ore Deposits.....		830.88
Instruments.....		710.06
Travelling Expenses.....		698.06
Investigation re Oil Shales.....		672.36
Publication of Maps.....		376.84
Investigation of Explosives.....		284.85
Mineral Statistics.....		166.18
Balance unexpended.....		56,054.48
	<u>\$258,558.09</u>	<u>\$258,558.09</u>

SUMMARY	Vote.	Expenditure.	Unexpended Balance.
Civil Government Salaries.....	\$ 62,050.00	\$ 60,184.08	\$ 1,865.92
Investigation of ore deposits, economic minerals, etc.....	75,000.00	73,345.53	1,654.47
Printing, books, stationery, apparatus, chemical laboratories expenses, miscellaneous.....	55,000.00	42,219.87	12,780.13
Investigation of metallurgical problems of economic importance.....	9,300.00	9,297.37	2.63
Investigation of manufacture and storage of ex- plosives in Canada.....	5,000.00	284.85	4,715.15
Investigation re quartz and copper deposits in Yukon.....	9,200.00	8,430.59	769.41
Compassionate allowance to Mrs. Sjostedt, per Bill 193.....	500.00	500.00	
Zinc Investigation, per Bill 182.....	41,937.94	7,671.17	34,266.77
	<u>\$257,987.94</u>	<u>\$201,933.46</u>	<u>\$56,054.48</u>

SESSIONAL PAPER No. 26a

ACCOUNTANT'S STATEMENT MINES BRANCH.

Statement of Appropriations and Expenditure 1913-14.¹

Mines Branch.	Grant.	Expenditure.	Grant not used.
Investigation of ore deposits, economic minerals, peat bogs, determination of fuel values of coals, lignite and peat of Canada, including wages of machinist and labourers, and additional machinery; investigation of ore dressing, including wages of labourers, machinery and equipment of laboratory; collection of information regarding minerals, and metallurgical industries and operations.....	\$77,000.00	\$54,799.29	\$22,200.71
Publication of reports, translation of reports into French, purchase of books, stationery, chemical laboratories' expenses, apparatus, instruments, office contingencies, additional assistance....	69,500.00	69,030.90	469.10
Investigation of metallurgical problems of economic importance.....	10,000.00	9,999.86	.14
For apparatus and equipment, salaries of inspectors, chemists, machinist, clerical assistance, and travelling expenses in connexion with the investigations of the manufacture and storage of explosives in Canada	55,000.00	480.24	54,519.76
Zinc investigations per Bill No. 182.....	34,266.77	30,948.99	3,317.78
Investigation of quartz and copper deposits in the Yukon.....	9,000.00	8,620.36	379.64
	<u>\$254,766.77</u>	<u>\$173,879.64</u>	<u>\$80,887.13</u>
DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C.			
Maintenance of Assay Office, Vancouver, B.C.....	27,000.00	14,868.83	12,131.17

(Signed) JNO. MARSHALL,
Accountant.

May 22, 1914.

¹ This financial statement covers nine months of the calendar year which is also the period of greatest activity. Therefore it has been deemed advisable to include the financial report most closely associated with the work described in this summary report. As the statement for the previous financial year was not included in the last summary report 1912, it is also published herewith.

STATEMENT OF APPROPRIATION AND EXPENDITURE BY MINES BRANCH FOR YEAR ENDING MARCH 31, 1914.

	Appropriation.	Expenditure.
Amounts voted by Parliament.....	\$329,341.77	
Receipts for Assays and Analyses.....	377.85	
Civil List Salaries.....		\$68,199.86
Publication of Reports.....		46,564.75
Zinc Investigations.....		28,613.58
Fuel Testing Plant, Ottawa.....		15,782.82
Concentrating Laboratory.....		15,775.53
Metallurgical Investigations.....		9,999.86
Quartz Investigations.....		8,620.36
Printing, stationery, books, mapping material.....		8,242.66
Investigation of Iron Ore deposits.....		7,876.67
Wages, outside service.....		5,916.41
Laboratory.....		3,358.99
Investigation of Peat and Coal.....		3,213.71
International Geological Congress.....		2,627.89
Investigation of Tar Sands.....		2,610.57
Monograph on Petroleum and Natural Gas.....		2,002.85
Miscellaneous.....		1,985.04
Investigation of Copper deposits.....		1,828.51
Publication of Maps.....		1,663.36
Monograph on Building Stones.....		1,428.89
Instruments.....		668.18
Travelling Expenses.....		655.08
Investigation of Explosives.....		480.24
Monograph on Mica.....		450.60
Mineral Statistics.....		404.90
Investigation of Salt Deposits.....		351.23
Coal Tests.....		239.24
Legal Fees.....		215.00
Investigation of Oil Shales.....		155.16
Investigation of ore deposits.....		135.80
Investigations of Manufacturer's Raw Materials.....		54.20
Balance unexpended.....		89,597.68
	<u>\$329,719.62</u>	<u>\$329,719.62</u>

SUMMARY.	Vote.	Expenditure.	Unexpended Balance.
Civil Government Salaries.....	\$74,575.00	\$68,199.86	\$ 6,375.14
Investigation of ore deposits, economic minerals, etc.	77,000.00	54,799.29	22,200.71
Printing, books, stationery, apparatus, chemical laboratories expenses, miscellaneous.....	69,500.00	69,030.90	469.10
Investigation of metallurgical problems of economic importance.....	10,000.00	9,999.86	.14
Investigation of manufacture and storage of ex- plosives in Canada.....	55,000.00	480.24	54,519.76
Investigation re quartz and copper deposits in Yukon.....	9,000.00	8,620.36	379.64
Zinc investigation, per Bill 182.	34,266.77	28,613.58	5,653.19
	<u>\$329,341.77</u>	<u>\$239,744.09</u>	<u>\$89,597.68</u>

APPENDICES.

APPENDIX I.

**Preliminary Report on the Mineral Production of Canada,
during the Calendar Year 1913.**

EUGENE HAANEL, Ph.D.,
Director of Mines.

SIR,—I beg to submit herewith, the annual preliminary report on the mineral production of Canada in 1913.

The figures for production in 1913, while subject to revision, are based upon direct returns from mine and smelter operators and are fairly complete.

Special acknowledgments are due to those operators who have promptly furnished reports of their operations during the year.

When complete returns shall have been received the usual annual report will be prepared containing in greater detail the final statistics as well as information relating to exploration, development, prices, markets, imports, and exports, etc.

I am, sir, your obedient servant,

John McLeish.

Division of Mineral Resources and Statistics,
February 26, 1914.

SESSIONAL PAPER No. 26a

PRELIMINARY REPORT ON THE MINERAL PRODUCTION OF CANADA, 1913.

STATISTICS SUBJECT TO REVISION.

The preliminary report on mineral production in Canada in 1913 presented herein shows a total value of production in the year just closed of \$144,031,047. Although estimates have been made in some cases where complete returns were not available it is probable that the final record will be a revision upward. The total value of the production in 1912 was \$135,048,296 compared with which the 1913 output shows an increase of \$8,982,751 or 6.65 per cent. In view of the large increase over all previous years made in mineral production in 1912 and the general trade depression and industrial restriction experienced during the latter part of 1913, the industry would appear to have made in the aggregate very satisfactory progress. The average production per capita in 1913 was \$18.57 as against \$18.27 in 1912, and \$14.93 in 1910.

The record of annual mineral production in Canada since 1886 shows the rapid growth of the industry, not only has the total output increased from a little over \$10,000,000 in 1886 to its present output but the average production per capita has increased from \$2.23 per capita to \$18.57, or eight times the rate shown by the first record.

Annual Mineral Production in Canada since 1886.

Year.	Value of production.	Value per capita.	Year.	Value of production.	Value per capita.
	\$	\$ cts.		\$	\$ cts.
1886.....	10,221,255	2 23	1900.....	64,420,877	12 04
1887.....	10,321,331	2 23	1901.....	65,797,911	12 16
1888.....	12,518,894	2 67	1902.....	63,231,836	11 36
1889.....	14,013,113	2 96	1903.....	61,740,513	10 83
1890.....	16,763,353	3 50	1904.....	60,082,771	10 27
1891.....	18,976,616	3 92	1905.....	69,078,999	11 49
1892.....	16,623,415	3 39	1906.....	79,286,697	12 81
1893.....	20,035,082	4 04	1907.....	86,865,202	13 75
1894.....	19,931,158	3 98	1908.....	85,557,101	13 16
1895.....	20,505,917	4 05	1909.....	91,831,441	13 70
1896.....	22,474,256	4 38	1910.....	106,823,623	14 93
1897.....	28,485,023	5 49	1911.....	103,220,994	14 42
1898.....	38,412,431	7 32	1912.....	135,048,296	18 27
1899.....	49,234,005	9 27	1913.....	144,031,047	18 75

The continuance during 1913 of the labour strike at the mines of the Canadian Collieries (Dunsmuir) Ltd., and its extension to the other collieries on Vancouver Island, seriously restricted the coal output from this district. The total value of the metals was also somewhat smaller than it might otherwise have been because of the slightly lower average prices obtained for copper and silver. A restricted demand was also reported during the latter part of the year for brick and other clay products and structural materials. While these are some of the influences that have tended to curtail the mineral output during the year, there have on the other hand been important increases in the produc-

tion of gold, nickel, and lead, among the metals, in asbestos, natural gas and many of the other less valuable non-metal products and in cement, resulting in the net increases already shown.

The production of the more important metals and minerals is shown in the following tabulated statement in which the figures are given for the two years 1912 and 1913 in comparative form, and the increase or decrease in value shown. Tabulated statements in greater detail will be found on subsequent pages of this pamphlet.

—	1912.		1913.		Increase (+) or decrease (-) in value.
	Quantity.	Value.	Quantity.	Value.	
		\$		\$	\$
Copper.....Lbs.	77,832,127	12,718,548	76,975,832	11,753,440	- 965,108
Gold.....Ozs.	611,885	12,648,794	784,525	16,216,131	+ 3,567,337
Pig iron..... ¹ Tons.	1,014,587	14,550,999	1,128,967	16,540,012	+ 1,989,013
Lead.....Lbs.	35,763,476	1,597,554	37,662,703	1,754,705	+ 157,151
Nickel....."	44,841,542	13,452,463	49,676,772	14,903,032	+ 1,450,569
Silver.....Ozs.	31,955,560	19,440,165	31,750,618	18,984,012	- 456,153
Other metallic products.....		864,343		1,520,072	+ 655,729
Total.....		75,272,866		81,671,404	+ 6,398,538
Less pig iron credited to imported ores.....Tons.	978,232	14,100,113	1,055,459	15,543,583	+ 1,443,470
Total metallic.....		61,172,753		66,127,821	+ 4,955,068
Asbestos and Asbestic...Tons.	136,301	3,137,279	161,086	3,849,925	+ 712,646
Coal....."	14,512,829	36,019,044	15,115,089	36,250,311	+ 231,267
Gypsum....."	578,458	1,324,620	639,698	1,477,589	+ 152,969
Natural gas.....M. ft.	15,286,803	2,362,700	20,345,763	3,338,314	+ 975,614
Petroleum.....Brls.	243,336	345,050	228,080	406,439	+ 61,389
Salt.....Tons.	95,053	459,582	100,791	491,280	+ 31,698
Cement.....Brls.	7,132,732	9,106,556	8,658,922	11,227,284	+ 2,120,728
Clay products.....		10,575,869		9,673,067	- 902,802
Lime.....Bush.	8,475,839	1,844,849	7,671,381	1,605,812	- 239,037
Stone.....		4,726,171		5,199,204	+ 473,033
Miscellaneous non-metallic.....		3,973,823		4,384,001	+ 410,178
Total non-metallic.....		73,875,543		77,903,226	+ 4,027,683
Grand total.....		135,048,296		144,031,047	+ 8,982,751

¹Short tons throughout.

Of the total production in 1913 a value of \$66,127,821 or 45.9 per cent is credited to the metals and \$77,903,226 or 54.1 per cent to the non-metallic products. The increase over the value for 1912 in metallic products was \$4,955,068 or 8.1 per cent and in non-metallic products \$4,027,683 or 5.45 per cent.

There was an increased production of each of the metals except copper and silver, the most important increase being in gold with 28 per cent. Pig iron increased 11.3 per cent in tonnage, lead 5.3 per cent, and nickel 10.8 per cent. The falling off in copper was only 1.1 per cent in quantity although 7.6 per cent in total value, and for silver 0.6 per cent only in number of ounces and 2.3 per cent in value, slightly lower average prices having been obtained for these metals.

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Among non-metallic products increases are shown in all the important products except clays and lime. The largest increase was in natural gas with 41 per cent in value. The cement output was greater by 21 per cent in quantity, asbestos 18 per cent, coal 4 per cent, gypsum 10·5 per cent, salt 6·04 per cent. In the case of petroleum there was a falling off of 6 per cent in quantity but on account of higher prices an increase of nearly 18 per cent in total value.

The decreases in clay products and lime were respectively 8·5 per cent and 12·9 per cent.

MINERAL PRODUCTION BY PROVINCES, 1912 and 1913.

	1912.		1913.	
	Value of Production.	Per cent of total.	Value of Production.	Per cent of total.
	\$	%	\$	%
¹ Nova Scotia.....	18,922,236	14·01	19,305,545	13·40
New Brunswick.....	771,004	0·57	1,049,932	0·73
Quebec.....	11,656,998	8·63	13,303,649	9·24
Ontario.....	51,985,876	38·50	58,697,602	40·75
Manitoba.....	2,463,074	1·83	2,211,159	1·54
Saskatchewan.....	1,165,642	0·86	899,233	0·62
Alberta.....	12,073,589	8·94	13,844,622	9·61
British Columbia.....	30,076,635	22·27	28,529,081	19·81
Yukon.....	5,933,242	4·39	6,190,224	4·30
Dominion.....	135,048,296	100·00	144,031,047	100·00

¹Includes a small production of lime from Prince Edward Island.

The record of production by provinces given in the preceding table shows the relative importance of the several provinces in practically the same order as last year with the exception that Saskatchewan replaces New Brunswick in last position due to a falling off in the coal and structural material production in the former Province and an increase in the coal, gypsum and natural gas production in the latter. Ontario has the largest output with a value of \$58,697,602, or 40·75 per cent of the total, a slightly higher proportion than in 1912. British Columbia is second with a value of \$28,529,081 or 19·81 per cent of the total, a relative falling off; Nova Scotia takes third place with a total production of \$19,305,545 or 13·4 per cent; Alberta fourth, with \$13,844,622 or 9·6 per cent; Quebec fifth, with \$13,303,649 or 9·24 per cent.

Increases are shown in each of the provinces with the exception of Manitoba, Saskatchewan and British Columbia. The largest increase—36 per cent,—is exhibited by New Brunswick. The increases in the other provinces were respectively: Alberta 14·7 per cent; Quebec 14·1 per cent; Ontario 12·9 per cent; Yukon 4·3 per cent; Nova Scotia 2·0 per cent. The decreases were Saskatchewan nearly 23 per cent, Manitoba 10 per cent, and British Columbia 5 per cent.

It should be remembered in dealing with these comparisons that Nova Scotia in the above record is given no credit on account of the large iron smelting and steel making industries at Sydney, New Glasgow, etc. The pig iron made here is entirely from imported ore and naturally is not credited as a Canadian mine output. The same remark applies to a large percentage of the pig iron production in Ontario as well as to the production of aluminium in Quebec.

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THE MINERAL PRODUCTION OF CANADA IN 1913.

Subject to Revision.

Product.	Quantity.	Value.
METALLIC.		\$
Copper, value at 15.269 cents per pound.....Lbs.	76,975,832	11,753,440
Gold.....Ozs.	784,525	16,216,131
Pig iron from Canadian ore.....Tons.	73,508	996,429
Iron ore sold for export....."	216,614	430,561
Lead, value at 4.659 cents per pound.....Lbs.	37,662,703	1,754,705
Nickel, value at 30 cents per pound....."	49,676,772	14,903,032
Silver, value at 59.791 cents per oz.....Ozs.	31,750,618	18,984,012
Cobalt and nickel oxides.....		689,511
Zinc ore.....Tons.	7,535	400,000
Total.....		66,127,821
NON-METALLIC.		
Actinolite.....Tons.	66	720
Arsenic, white....."	1,692	101,463
Asbestos....."	136,951	3,830,909
Asbestic....."	24,135	19,016
Coal....."	15,115,089	36,250,311
Corundum....."	1,177	137,036
Feldspar....."	15,935	56,841
Graphite....."	2,162	90,282
Grindstones....."	4,284	43,900
Gypsum....."	639,698	1,477,589
Magnesite....."	770	4,620
Mica....."		170,112
Mineral pigments—		
Barytes....."	641	6,410
Ochres....."	5,987	41,774
Mineral water.....		173,677
Natural gas.....M. cu. ft.	20,345,763	3,338,314
Peat.....Tons.	2,600	10,100
Petroleum, value at \$1.782 per barrel.....Brls.	228,080	406,409
Phosphate (returns not complete).....Tons.	25	237
Pyrites....."	228,811	638,115
Quartz....."	78,261	169,848
Salt....."	100,791	491,282
Talc....."	12,250	45,980
Tripolite....."	620	12,138
Total.....		47,517,155
STRUCTURAL MATERIALS AND CLAY PRODUCTS.		
Cement, Portland.....Brls.	8,658,922	11,227,284
Clay products—		
Brick, common, pressed, paving.....		7,709,224
Sewerpipe.....		920,973
Fireclay, drain tile, pottery, etc.....		1,037,870
Kaolin.....Tons.	500	5,000
Lime.....Bush.	7,671,381	1,605,812
Sand and gravel.....		1,712,256
Sand-lime brick.....		962,004
Slate.....Sq.	1,432	6,444
Stone—		
Granite.....		1,644,183
Limestone.....		3,087,991
Marble.....		250,373
Sandstone.....		216,657
Total structural materials and clay products.....		30,386,071
All other non-metallic.....		47,517,155
Total value, metallic.....		66,127,821
Grand total, 1913.....		144,031,047

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The average monthly prices of the metals in cents per pound for several years past are shown herewith, and reference is made elsewhere to the changes in prices here shown in 1913 as compared with 1912. A peculiar feature of the changes is the fact that there was a falling off in the average price of lead on the New York market but an increase in the average price in London.

	1908	1909	1910	1911	1912	1913
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Copper, New York.....	13.208	12.982	12.738	12.376	16.341	15.269
Lead " ".....	4.200	4.273	4.446	4.420	4.471	4.370
" London.....	2.935	2.839	2.807	3.035	3.895	4.072
" Montreal ¹	3.364	3.268	3.246	3.480	4.467	4.659
Nickel, New York.....	43.000	40.000	40.000	40.000	40.000	40.000
Silver ".....	52.864	51.503	53.486	53.304	60.835	59.791
Spelter ".....	4.720	5.503	5.520	5.758	6.943	5.648
Tin ".....	29.465	29.725	34.123	42.281	46.096	44.252

¹Quotations furnished by Messrs. Thomas Robertson and Company, Montreal, Que.

SMELTER PRODUCTION.

General statistics showing the quantities of ores treated at smelters and the quantities of refined metals or smelter products obtained have been collected by this Branch since 1908. It should be explained that the accompanying statistics include the treatment of a small quantity of imported ores chiefly in the British Columbia smelters.

The total quantity of ore, concentrates, etc., treated in 1913 was 3,027,085 tons as compared with 3,005,410 tons in 1912.

The ores treated may be conveniently classified as follows:—

	1911	1912	1913
	Tons.	Tons.	Tons.
Nickel-copper ores.....	610,834	725,065	823,403
Silver-cobalt-nickel-arsenic ores.....	9,330	8,097	5,818
Lead and other ores treated in lead furnaces.....	55,408	59,932	78,110
Copper-gold-silver ores.....	1,517,981	2,212,316	2,119,754
Total.....	2,193,553	3,005,410	3,027,085

The products obtained in Canada from the treatment of these ores include refined lead produced at Trail, B.C., and fine gold, fine silver, copper sulphate and antimony produced from the residues of the lead refinery there; silver bullion, white arsenic, nickel oxide and cobalt oxide produced in Ontario from the Cobalt District ores. In addition to these refined products blister copper, copper matte, nickel-copper matte, cobalt material or mixed cobalt and nickel oxides are produced and exported for refining outside of Canada.

The aggregate results of smelting and refining operations may be summarized as in the next table. Unfortunately the figures cannot be taken to represent the total production from smelting ores mined in Canada since considerable quantities of copper and silver ores are still shipped to other smelters outside of Canada for smelting.

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Refined products produced and metals contained in refined smelter products exported.	1912		1913	
	Refined products.	Metals contained in matte blister, base bullion and speiss.	Refined products.	Metals contained in matte blister, base bullion and speiss.
Gold.....Ozs.	12,118	184,815	11,977	213,279
Silver....."	17,572,217	686,171	13,789,709	934,601
Lead (including secondary lead) ..Lbs.	35,893,190		39,468,729	
Copper....."		58,405,910		59,245,722
Copper Sulphate....."	87,110		130,533	
Nickel....."		44,841,542		49,676,772
¹ Nickel and Cobalt oxides, etc."	349,054		1,644,185	
White arsenic....."	4,090,768		3,384,249	

¹Nickel oxide, cobalt oxide and cobalt material, speiss, etc., not all completely refined.

Smelter products shipped out of Canada for refining were: blister copper carrying gold and silver values, 15,270 tons in 1913, as compared with 17,063 tons in 1912; copper matte carrying gold and silver values, 5,159 tons in 1913 as against 6,727 tons in 1912, and bessemer nickel-copper matte carrying small gold and silver values as well as metals of the platinum group 47,150 tons in 1913, as compared with 41,925 tons in 1912.

Gold.

The gold production of 1913 is estimated at \$16,216,131, which compared with the production of the previous year shows an increase of \$3,567,337.

The Yukon placer production in 1913 is estimated at \$5,835,554 as against \$5,576,493 in 1912, the total amount on which royalty was paid during the calendar year according to the records of the Department of Interior being 352,900.04 ounces in 1913, and 335,015.67 ounces in 1912.

The British Columbia production in 1913 was \$6,136,900, of which the placer production, as estimated by the Provincial Mineralogist, was \$540,000, smelter recoveries and bullion from milling ores being estimated as \$5,596,900.

The main feature of the year was the large increase from the Porcupine district of Ontario.

British Columbia and the Yukon also show substantial increases, while the estimates for Nova Scotia and Quebec show decreases.

The export of gold-bearing dust, nuggets, gold in ore, etc., in 1913 were valued at \$12,770,838.

Gold in bars, blocks, ingots, etc., were imported in 1913 to the value of \$840,435.

Silver.

The estimated production of silver in 1913 was 31,750,618 fine ounces valued at \$18,984,012, a decrease of 204,942 ounces, and \$456,153 from 31,955,560 ounces valued at \$19,440,165 in 1912.

Of the 1913 production 28,452,737 ounces were from Ontario, and 3,208,122 from British Columbia.

For British Columbia the figures represent the recovery in mill bullion or as silver contained in smelter products, while for Ontario the figures represent

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the silver contained in gold ores milled or smelted and in bullion shipments from Cobalt to which is added the silver contents of the Cobalt ore and concentrate shipped, less five per cent, allowed for smelter losses.

The total shipments of ore and concentrates from the mines of Cobalt and the adjacent districts were about 44,106 tons, containing approximately 22,031,564 fine ounces, in addition to which 7,482,833 fine ounces were shipped as bullion. Of this tonnage about half was treated in the camp itself in customs reduction works.

In Quebec the silver was derived from the pyritic ores of the Eastern Townships.

The exports of silver in ore, etc., as reported by the Customs Department, were 37,371,569 ounces valued at \$21,441,220. There was also an importation of silver in bars, blocks, sheets, etc., valued at \$840,245.

The price of silver in New York varied between a maximum of $63\frac{3}{4}$ cents in January and a minimum of $56\frac{7}{8}$ cents per ounce in March, the average monthly price being 59.791 cents per ounce compared with an average of 60.835 cents in 1912.

Copper.

The Canadian production of copper is represented by the copper contents of smelter products, matte, blister copper, etc., together with the amount of copper contained in ores exported, estimated as recoverable.

The total production on this basis in 1913 was 76,975,832 pounds valued at \$11,753,440 as compared with 77,832,127 pounds valued at \$12,718,548 in 1912, a decrease in quantity of 856,295 pounds and in value of \$965,108.

Quebec province is credited with a production of 3,455,887 pounds as against 3,282,210 pounds in 1912, the increase being due to the increased production from the pyritic ores of the Eastern Townships.

Ontario's production in 1913 was 25,884,836 pounds as compared with 22,250,601 pounds in 1912 being mainly derived from the nickel-copper ores of the Sudbury district.

British Columbia had an output of 45,791,579 pounds.

From the Yukon the Pueblo mine was the heaviest shipper.

The New York price of electrolytic copper varied during the year between 17.45 cents per pound in January and 14.05 cents in December, the average for the year being 15.269 cents as against an average monthly price of 16.341 cents in 1912.

The total imports of copper in 1913 were valued at \$7,415,008, divided into crude and manufactured 41,011,961 pounds valued at \$6,935,822, other manufactures valued at \$371,226, copper sulphate 2,037,714 pounds valued at \$107,960.

The exports of copper were: fine in ore, matte, etc., 81,879,080 pounds valued at \$9,479,480, black in pigs 771,280 pounds valued at \$123,431.

Lead.

The total smelter production of lead in 1913 was 39,468,729 pounds, but this includes lead from American ores and lead contained in scrap, etc., re-smelted, the recovery from Canadian ores being 37,662,703 pounds valued at \$1,754,705, an average of 4.659 cents per pound, the average wholesale or producer's price of pig lead in Montreal for the year.

In 1912 the production was 35,763,476 pounds valued at \$1,597,534.

The shipments were practically all from British Columbia mines in 1913, though a small production is reported from Ontario and the Yukon.

The mines of British Columbia were very active during the year and the total lead contents in ores shipped is estimated as slightly in excess of 54,000,000 pounds. Allowing for "lag" and the losses due to smelting, the increased difference between ore contents and smelter recovery would indicate that a considerable amount of lead ore was in stock at the close of the year.

The exports of lead ore, etc., are given as 329,960 pounds valued at \$9,136. The total value of the imports of lead and lead products in 1913 was \$1,-215,434 including old scrap and pig 11,199,500 pounds valued at \$464,117, manufactured lead 9,865,980 pounds valued at \$320,797, manufactures N.O.P. \$155,179, and lithargè and lead pigments \$275,341.

The average monthly price of lead in Montreal during 1913 was 4.659 cents. This is the producer's price for lead in car lots as per quotations kindly furnished by Messrs. Thos. Robertson and Co.

The average monthly price of lead in New York during the year was 4.370 cents and in London £18.743 per long ton equivalent to 4.072 cents per pound.

The amount of bounty paid during the twelve months ending December 31, 1913, on account of lead production was \$57,956.70 as compared with \$118,-425.74 in 1912.

Nickel.

There was a greatly increased output in 1913 from the mining and smelting of the nickel-copper ores of Sudbury district, Ontario, the companies operating being the Canadian Copper Company and the Mond Nickel Company, operating mines and smelters, and the British America Nickel Corporation developing its ore bodies. In addition shipments were made from the Alexo mine at Kelso Mines to the Mond smelter at Coniston.

During the year the Mond Nickel Company completed their new smelter at Coniston.

The ore is smelted to a Bessemer matte containing 77 to 82 per cent of the combined metals and shipped in that form to Great Britain and the United States for refining. A portion of the matte produced by the Canadian Copper Company is used for the direct production of monel metal, an alloy of nickel and copper without the intermediate refining of either metal.

There is also a small recovery of nickel in the form of nickel oxide from the Cobalt District ores.

The total production of matte in 1913 was 47,150 tons valued by the producers at the smelters at \$7,076,945, an increase of 5,255 tons or more than 12½ per cent, over the production of 1912. The metallic contents were copper, 25,875,546 pounds and nickel 49,676,772 pounds. The amount of ore smelted was 823,403 tons, which included shipments from the Alexo mentioned above.

The aggregate results of the operations on the nickel ores during the past four years were as follows, in tons of 2,000 pounds.

	1910	1911	1912	1913
	Tons of 2,000 lbs.	Tons of 2,000 lbs.	Tons of 2,000 lbs.	Tons of 2,000 lbs.
Ore mined.....	652,392	612,511	737,584	784,697
Ore smelted.....	628,947	610,834	725,065	823,403
Bessemer matte produced.....	35,033	32,607	41,925	47,150
Copper content of matte.....	9,630	8,966	11,116	12,938
Nickel " ".....	18,636	17,049	22,421	24,838
Spot value of matte.....	\$5,380,064	\$4,945,592	\$6,303,102	\$7,076,945

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	Lbs.	Lbs.	Lbs.	Lbs.
Nickel contained in matte, etc.—				
Exported to Great Britain.....	5,335,331	5,023,393	5,072,867	5,164,512
“ United States.....	30,679,451	27,596,578	39,148,993	44,224,119
“ Other Countries.....				70,386
	36,014,782	32,619,971	44,221,860	49,459,017

The price of refined nickel in New York remained constant throughout the year, quotations in the “Engineering and Mining Journal,” being for large lots, contract business 40 to 45 cents per pound. Retail spot from 50 cents for 500 pound lots up to 55 cents for 200 pound lots. The price for electrolytic is 5 cents higher.

Iron.

Iron Ore. — The iron ore shipments from Canadian mines during 1913 amounted to 307,634 short tons valued at \$629,843. These shipments included 92,386 tons of hematite and roasted siderite, 209,886 tons of magnetite and concentrates and 5,362 tons of titaniferous ore.

The total ore shipments in 1912 were 215,883 short tons valued at \$523,315 and included 128,912 tons classed as magnetite and 86,971 as hematite.

Exports of iron ore from Canada during 1913 were recorded by the Customs Department as 126,124 tons valued at \$426,681. These were from Ontario, New Brunswick, Nova Scotia and Quebec.

Imports of iron ore, according to Customs records, in 1913 were 1,942,325 tons valued at \$3,877,824.

Shipments from the Wabana mines, Newfoundland, in 1913 by the two Canadian mines operating there were 1,605,920 short tons, of which 1,048,432 tons were shipped to Sydney, and 557,488 tons to the United States and Europe.

Pig Iron.—The total production of pig iron in Canadian blast furnaces in 1913 was 1,128,967 tons of 2,000 pounds, valued at approximately \$16,540,012, as compared with 1,014,587 tons valued at \$14,550,990 in 1912.

Of the total production of 1913, 23,696 tons were made with charcoal as fuel and 1,105,271 tons with coke.

The classification of the production according to the purposes for which it was intended was as follows: Bessemer 265,685 tons, basic 614,845 tons, foundry and miscellaneous 248,437 tons. The amount of Canadian ore used during 1913 was 139,436 tons, imported ore 2,110,828 tons, mill cinder, etc., 33,583 tons.

The amount of coke used during the year was 1,417,148 tons, comprising 710,260 tons from Canadian coal and 706,888 tons of imported coke or coke made from imported coal. There were also used 2,206,191 bushels of charcoal. Limestone flux used amounted to 630,119 tons.

In connexion with blast furnace operations there were employed 1,589 men, and \$1,149,345 were paid in wages.

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The production of pig iron by provinces in 1912 and 1913 was as follows:

	1912			1913		
	Tons.	Value.	Value per Ton.	Tons.	Value.	Value per Ton.
		\$	\$ cts.		\$	\$ cts.
Nova Scotia.....	424,994	6,374,910	15 00	480,068	7,201,020	15 00
Ontario.....	589,593	8,176,089	13 87	648,899	9,338,992	14 39
	1,014,587	14,550,999	14 34	1,128,967	16,540,012	14 65

There was also a production in 1913 in electric furnaces of 8,075 tons of ferro alloys valued at \$493,018, compared with 7,834 tons valued at \$465,225 in 1912.

The exports of pig iron during the year are reported as 6,326 tons valued at \$351,646, an average of \$55.58 per ton. Probably the greater part of this is ferro-phosphorus produced at Buckingham and ferro-silicon and ferro-manganese produced at Welland.

There were imported during the year 235,843 tons of pig iron valued at \$3,234,877, charcoal pig iron 926 tons valued at \$12,528, and ferro-manganese, ferro-silicon, etc., 30,355 tons valued at \$940,443.

Asbestos.

Activity in the production of asbestos in 1913 was confined to the districts of Black Lake, Thetford, Robertsonville, and Danville in Quebec. None of the quarries formerly operated at East Broughton were worked, although small shipments were made by one firm from stock.

The output and shipments in 1913 exceeded those of all previous years, the increase in sales over 1912 being 22.75 per cent.

The total output in 1913 was 132,564 tons as against 102,759 tons in 1912, an increase of 29,805 tons or 29 per cent. The sales and shipments of asbestos fibre in 1913 were 136,951 tons valued at \$3,830,909 or an average of \$27.97 per ton as against sales in 1912 of 111,561 tons valued at \$3,117,572 or an average of \$27.95. Stock on hand at December 31, 1913, was reported as 20,786 tons, as compared with stocks of 23,288 tons at the beginning of the year.

The number of men employed in mines and mills was 2,951, and amount paid in wages \$1,687,957.

The total quantity of asbestos rock sent to mills is reported as 2,110,990 tons which with a mill production of 127,539 tons shows an average estimated content of about 6.04 per cent of fibre in the rock.

A new mill is in course of construction at Danville.

The output and sales of crude and mill stock separately is shown for 1912 and 1913 in tabulated statements following. The classification is based on valuation, crude No. 1, comprising material valued at \$200 per ton and upwards, and crude No. 2, under \$200; mill stock No. 1 includes mill fibre valued at from \$30 upwards, No. 2, from \$15 to \$30, and No. 3, under \$15.

The total sales of crude in 1913 were 5,660.3 tons valued at \$989,162 or an average of \$174.75 as against sales in 1912 of 5,662.9 tons valued at \$890,351 or an average of \$157.22, practically the same quantity but at a higher average price.

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The total sales of mill stock in 1913 were 131,291 tons valued at \$2,841,747 or an average of \$21.64 per ton as against 105,898 tons in 1912 valued at \$2,227,221, or an average of \$21.03 per ton, a large increase in quantity but at substantially the same average price.

There was a falling off in the amount of both crude and mill fibre, in stock at the end of the year.

Output, Sales, and Stocks in 1913.

	Output.		Sales.		Stock on hand Dec. 31.		
	Tons.	Tons.	Value.	Per ton.	Tons.	Value.	Per ton
			\$	\$ cts.		\$	\$ cts.
Crude No. 1.....	2,015.4	1,853.3	531,200	286 62	880.5	247,877	281 52
" 2.....	3,010	3,807	457,962	120 29	1,522	178,789	117 47
Mill stock No. 1.....	23,444	26,198	1,229,908	46 95	6,755	350,165	51 84
" 2.....	58,592	60,164	1,201,215	19 97	4,809	108,285	22 52
" 3..	45,503	44,929	410,624	9 14	6,820	54,604	8 01
Total asbestos.....	132,564.4	136,951.3	3,830,909	27 97	20,786.5	939,720	45 21
Asbestic.....		24,135	19,016	0 79			

Output, Sales, and Stocks in 1912.

	Output.		Sales.		Stock on hand Dec. 31.		
	Tons.	Tons.	Value.	Per ton.	Tons.	Value.	Per ton.
			\$	\$		\$	\$
Crude No. 1.....	1,458.8	1,937.9	510,154	263 25	866.8	221,289	255 29
" 2.....	3,290	3,725	380,197	102 07	2,789	303,063	108 66
Mill stock No.1.	21,522	21,679	945,994	43 64	8,059	379,904	47 14
" 2.....	36,872	44,819	895,322	19 79	6,301	132,970	21 10
" 3	39,616	39,400	385,905	9 79	5,272	45,976	8 72
Asbestos.....	102,758.8	111,560.9	3,117,572	27 95	23,287.8	1,083,202	46 51
Asbestic ...		24,740	19,707	0 80			

Exports of asbestos during the twelve months ending December 31, 1913, were 103,812 tons valued at \$2,848,047 as against 88,008 tons valued at \$2,349,353 exported in 1912. There was also an export of manufactures of asbestos in 1913 valued at \$73,446.

Coal and Coke.

The coal mining industry in Canada in 1913 was marked by an increased production in the Maritime Provinces of Nova Scotia and New Brunswick, and in the Province of Alberta, and a falling off in the Provinces of Saskatchewan and British Columbia. In the latter Province the decrease was entirely due to the continuance throughout the year of the labour strike in the mines on Vancouver Island. The lessened production in these two provinces was, however, more than offset by the increased output in Alberta and Nova Scotia so that the net result for the year was an increase of about 602,260 tons or 4·15 per cent.

The total production of marketable coal for the year comprising sales and shipments, colliery consumption and coal [used in making coke, etc., was 15,115,089 short tons, valued at \$36,250,311 as against 14,512,829 tons valued at \$36,019,044 in 1912. Nova Scotia shows an increase of 188,839 tons or 2·4 per cent, Alberta an increase of 903,800 tons or 27·9 per cent, Saskatchewan a decrease of 16,167 tons or 7·1 per cent, and British Columbia a decrease of 494,548 tons or 15·4 per cent. The figures for the Yukon represent for 1913 the production from the Tantalus field only, no record having as yet been received of the output below Dawson.

The production by provinces during the past three years is given below:—

Production of Coal by Provinces.

Province.	1911		1912		1913	
	Tons.	Value. \$	Tons.	Value. \$	Tons.	Value. \$
Nova Scotia.....	7,004,420	14,071,379	7,783,888	17,374,750	7,972,727	17,796,265
British Columbia....	2,542,532	7,945,413	3,208,997	10,028,116	2,714,449	8,482,653
Alberta.....	1,511,036	3,979,264	3,240,577	8,113,525	4,144,377	9,462,836
Saskatchewan.....	206,779	347,248	225,342	368,135	209,175	347,685
New Brunswick.....	55,781	111,562	44,780	89,560	70,311	140,622
Yukon Territory.....	2,840	12,780	9,245	44,958	4,050	20,250
Total.....	11,323,388	\$26,467,646	14,512,829	\$36,019,044	15,115,089	\$36,250,311

The exports of coal in 1913 were 1,562,020 tons valued at \$3,961,351, as compared with exports of 2,127,133 tons valued at \$5,821,593 in 1912, a falling off of 565,113 tons or over 26 per cent.

Imports of coal during the year included bituminous, round, and run of mine 10,743,473 tons, valued at \$21,756,658; bituminous slack 2,816,423 tons valued at \$4,157,622; and anthracite 4,642,057 tons valued at \$22,034,839; or a total of 18,201,953 tons valued at \$47,949,119.

The imports in 1912 were bituminous, run of mine, 8,491,840 tons valued at \$16,846,727; bituminous slack 1,915,993 tons valued at \$2,550,992, and anthracite 4,184,017 tons valued at \$20,080,388 or a total of 14,595,810 tons valued at \$39,478,037.

Thus the increase of imports of coal in 1913 amounted to a total of 3,606,143 tons or nearly 25 per cent. The increase in the imports of bituminous run of mine being 2,251,633 tons or 26·5 per cent, increased imports of slack 900,430 tons or 47 per cent, increased imports of anthracite 458,040 tons or 11 per cent.

The apparent consumption of coal during the year was 31,685,456 tons as against a consumption of 26,934,800 tons in 1912. Of the consumption in 1913 about 42·8 per cent was from Canadian mines and 57·2 per cent imported.

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Coke.—The total output of oven coke during 1913 was 1,517,133 tons of 2,000 lbs. made from 2,147,913 tons of coal of which 1,598,912 tons were mined in Canada and 549,001 tons imported. The total quantity of coke sold or used by the producers during the year was 1,530,499 tons valued at \$5,547,694.

In 1912 the total output was 1,406,028 tons and the quantity sold or used by the producers 1,411,229 tons valued at \$5,164,331.

The output by provinces in 1913 was: Nova Scotia 720,526 tons, Ontario 411,643 tons, Alberta 65,104 tons and British Columbia 319,860 tons. That of Ontario was entirely from imported coal.

By-products from coke ovens recovered during the year included 10,608 tons ammonia sulphate; 8,371,600 gallons of tar, and 3,353,731 thousand feet of gas, and the total value would approximate \$866,150.

The ovens of the Acadia Coal Co. and Londonderry Iron and Mining Co. in Nova Scotia, the Atikokan Iron Co. in Ontario, the West Canadian Collieries and Leitch Collieries in Alberta and the Canadian Collieries, Ltd., in British Columbia, were idle throughout the year. At the end of the year there were 1,720 ovens in operation and 1,375 idle as follows: Nova Scotia 572 active, 376 idle; Ontario 110 active, 100 idle; Alberta 134 active, 233 idle; British Columbia 904 active, 666 idle.

The exports of coke during 1913 were 68,235 tons valued at \$308,410 and the imports 723,906 tons valued at \$2,180,830. In 1912 the exports were 57,744 tons valued at \$252,763 and the imports 628,174 tons valued at \$1,702,856.

Petroleum and Natural Gas.

The production of crude petroleum in Canada was still confined during 1913 to the old established fields in Ontario with a few barrels pumped from gas wells in New Brunswick.

The annual output has been steadily declining during the past six years and shows a further falling off in quantity produced in 1913 although owing to the higher price obtained for oil a larger total value is shown than for 1912.

A bounty of one and a half cents per imperial gallon is paid upon the production of crude petroleum, the Bounty Act being administered and payments made by the Department of Trade and Commerce. According to the records of this Department the total output of petroleum in 1913 was 228,080 barrels or 7,982,798 gallons on which a bounty of \$119,741.97 was paid. The total value of the production at the average price for the year \$1.782 per barrel was \$406,439.

The production in 1912 was 243,336 barrels or 8,516,762 gallons valued at \$345,050, or an average value of \$1.418 per barrel.

The average price per barrel at Petrolia during 1913 increased from a minimum on January 1 of \$1.65, to \$1.75 on April 16, \$1.84 on November 6, and \$1.89 on December 22.

The production in Ontario by districts as furnished by the supervisor of petroleum bounties was in 1913 as follows, in barrels: Lambton 155,747; Tilbury 26,824; Bothwell 34,349; Dutton 4,610; Onondaga 4,172 and Belle River 464, or a total of 226,166 barrels. In 1912 the production by districts was: Lambton 150,272; Tilbury 44,727; Bothwell 34,486; Dutton 4,335, and Onondaga 7,115, or a total of 240,935 barrels.

The production in New Brunswick in 1913 was 2,111 barrels as against 2,679 barrels in 1912 and 2,461 barrels in 1911.

Exports entered as crude mineral oil in 1913 were 3,650 gallons valued at \$379 and refined oil 24,273 gallons valued at \$3,188. There was also an export of naphtha and gasolene of 17,875 gallons valued at \$4,284.

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The total value of the imports of petroleum and petroleum products in 1913 was \$13,339,326 as against a value of \$11,978,053 in 1912. The imports have been increasing rapidly during the past few years.

Crude oil is being extensively used as a fuel on the Pacific Coast in both steamships and locomotives and the wide use of the gasoline motor has created a big demand for gasoline. The total imports of petroleum oils, crude and refined, in 1913 were 222,779,293 gallons valued at \$13,230,429, in addition to 1,628,837 pounds of wax and candles valued at \$108,897. The oil imports included crude oil 162,062,201 gallons, valued at \$5,250,835; refined and illuminating oils 19,393,627 gallons valued at \$1,386,440; gasoline 29,525,170 gallons valued at \$4,822,941; lubricating oils 6,789,451 gallons valued at \$1,172,986 and other petroleum products 5,008,844 gallons valued at \$597,227.

The total imports in 1912 were 186,787,484 gallons of petroleum oils crude and refined, valued at \$11,858,533, in addition to 2,144,006 pounds of paraffin wax and candles valued at \$119,520. The oil imports included: crude oil 120,082,405 gallons valued at \$3,996,842; refined and illuminating oils 14,748,218 gallons valued at \$1,012,735; gasoline 40,904,598 gallons valued at \$5,347,767; lubricating oils 6,763,800 gallons valued at \$1,077,712, and other petroleum products 4,288,463 gallons valued at \$423,477.

There was an increased importation in 1913 of all classes of oil with the exception of gasoline, the increases being most pronounced in crude oil and refined illuminating oil.

Natural Gas.—There was comparatively little change in the production of natural gas in Ontario but a large increase in the production in New Brunswick and in Alberta. The total production in 1913 was approximately 20,345 million feet valued at \$3,338,314 of which 828 million feet valued at \$174,006 was from New Brunswick; 12,487 million feet valued at \$2,092,400 from Ontario, and 7,030 million feet valued at \$1,071,908 from Alberta.

The production in 1912 was reported as 15,287 million feet valued at \$2,362,700 and included 174 million feet from New Brunswick valued at \$36,549; 12,529 million feet from Ontario valued at \$2,036,245, and 2,584 million feet from Alberta valued at \$289,906.

These values represent as closely as can be ascertained the value received by the owners or operators of the wells for gas produced and sold or used. The values do not represent what consumers have to pay since in cases where transmission is by separately operated pipe line companies such cost is not included.

Cement.

The financial stringency during 1913 had an immediate effect in the restriction of building operations of all kinds and its results are shown in the statistics of production and consumption of structural materials. In the case of cement, while a very substantial increase in production is shown, this has seemed chiefly to displace imported material, the increase in consumption being only 4 per cent as against an increased production of 24 per cent. Canadian mills supplied over 97 per cent of the consumption in 1913 as against 83 per cent in 1912. The industry has been marked by the extension of old and the completion of new plants, the latter west of the great lakes. The total capacity of completed plants at the end of the year being about 50,000 barrels per day as compared with 36,500 barrels at the end of 1912. New plants were placed in operation at Winnipeg, Marlboro west of Edmonton, Princeton, B.C., and at Tod Inlet, Vancouver island, B.C. The plants of the Imperial Portland Cement Co. at Owen Sound and of the Crown Portland Cement Co. were not operated during the year.

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The total quantity of Portland cement, including slag cement and natural Portland, made in 1913 was 8,880,983 barrels, an increase of 1,739,979 barrels or 24 per cent over 1912. The quantity of Canadian cement sold or used was 8,658,922 barrels valued at \$11,227,284 or \$1.29 $\frac{2}{3}$ per barrel, an increase of 1,526,190 barrels or 22 per cent and \$2,120,728 or 23 per cent in total value. The total imports of cement were 889,324 cwt. equivalent to 254,092 barrels of 350 pounds each and valued at \$409,303 or an average of \$1.61 per barrel, as compared with imports of 1,434,413 barrels valued at \$1,969,529 or an average of \$1.37 in 1912. The total consumption of Portland cement, therefore, neglecting a small export, was 8,913,014 barrels as compared with a consumption of 8,567,145 barrels in 1912, an increase of 345,869 barrels or only 4 per cent.

Detailed statistics of production during each of the four past years are shown as follows:—

—	1910	1911	1912	1913
	Brls.	Brls.	Brls.	Brls.
Portland Cement sold.....	4,753,975	5,962,915	7,132,732	8,658,922
“ manufactured.....	4,396,282	5,677,539	7,141,004	8,880,983
Stock on hand Jan. 1.....	1,189,731	918,965	894,822	866,138
“ Dec. 31.....	832,038	903,589	903,094	1,088,199
Value of cement sold.....	\$6,412,215	\$7,644,537	\$9,106,556	\$11,227,284
Wages paid.....	1,409,715	2,103,838	2,623,902	.....
Men employed..	2,220	3,010	3,461	.....

The average price per barrel at the works in 1913 was \$1.29 $\frac{2}{3}$ as compared with \$1.28 in 1912 and \$1.34 in 1911 and 1910.

The imports of cement in 1913 included 77,356 barrels from Great Britain, 172,298 barrels from the United States, 3,443 barrels from Hong Kong, and 995 barrels from other countries. The average price per barrel was \$1.61 as against an average of \$1.37 on imports in 1912.

The consumption of Portland cement during each of the past five years was as follows:—

ANNUAL CONSUMPTION OF PORTLAND CEMENT.

Calendar Year.	Canadian.		Imported.		Total.
	Brls.	%	Brls.	%	Brls.
1909.....	4,067,709	97	142,194	3	4,209,903
1910.....	4,753,975	93	319,310	7	5,103,285
1911.....	5,692,915	90	661,916	10	6,354,831
1912.....	7,132,732	83.3	1,434,413	16.7	8,567,145
1913.....	8,658,922	97.1	254,092	2.9	8,913,014

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Exports of Products of the Mines and Manufactures of Mine Products,
Calendar Year, 1913.

		Quantity.	Value.
			\$
Arsenic	Lbs.	2,606,767	107,094
Asbestos.....	Tons.	103,812	2,848,047
" sand.....	"	24,766	138,737
Coal.....	"	1,562,020	3,961,351
Feldspar.....	"	15,966	62,767
Gold.....			12,770,838
Gypsum.....	Tons.	417,302	504,383
Copper, fine, in ore, etc.....	Lbs.	81,879,080	9,479,480
" black, in pigs, etc.....	"	771,280	123,431
Lead, metallic, in ore, etc.....	"	329,960	9,136
Nickel, in ore, etc.....	"	49,459,017	5,195,560
Platinum.....	Ozs.	158	7,929
Silver.....	"	37,371,569	21,441,220
Mica.....	Lbs.	817,152	240,775
Mineral pigments.....	Cwt.	39,124	18,931
Mineral water.....	Gals.	3,640	525
Oil, mineral, crude.....	"	3,650	371
" refined.....	"	24,273	3,186
Ores—			
Corundum.....	Tons.	1,077	121,741
Iron.....	"	126,124	426,681
Manganese.....	"	8	303
Other Ores.....	"	10,835	658,808
Plumbago.....	Cwt.	32,842	85,368
Pyrites.....	Tons.	46,066	211,640
Salt.....	Cwt.	4,609	3,047
Sand and gravel.....	Tons.	644,633	440,956
Stone, ornamental.....	"	1,942	687
" building.....	"	191,981	82,646
" crushed.....	"	4,814	3,126
Other articles.....			124,392
Total value products of mine.....			59,073,167
Manufactures—			
Agricultural Implements—			
Mowing machines.....	No.	24,044	847,253
Cultivators.....	"	7,795	201,758
Reapers.....	"	5,604	317,716
Drills.....	"	10,364	634,121
Harvesters and binders.....	"	23,194	2,439,319
Ploughs.....	"	15,450	465,505
Harrows.....	"	7,300	127,482
Hay rakes.....	"	9,846	247,445
Threshing machines.....	"	1,928	712,270
All other.....			503,235
Parts of.....			915,142
Asbestos, manufactures of.....			73,446
Bricks.....	M	977	8,579
Cement.....			1,739
Clay, manufactures of.....			27,201
Coke.....	Tons.	68,235	308,410
Acetate of lime.....	Lbs.	14,902,990	322,069
Acid sulphuric.....	"	2,494,740	15,295
Calcium carbide.....	"	5,163,577	153,702
Phosphorus.....	"	534,340	73,395
Earthenware, manufactures of.....			16,553
Fertilizers.....			2,439,923
Grindstones, manufactured.....			54,867
Gypsum or plaster, ground.....			5,795

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Exports of Products of the Mines and Manufactures of Mine Products, Calendar Year, 1913—*Concluded*.

		Quantity.	Value.
			\$
Iron and steel, manufactures of—			
Stoves.....	No.	1,371	23,858
Gas buoys and parts of.....			35,462
Castings, N.O.P.....			61,362
Pig iron.....	Tons.	6,326	351,646
Machinery—			
Linotype machines.....			9,631
Machinery, N.O.P.....			435,333
Sewing machines.....	No.	8,122	114,438
Washing machines.....			15,872
Typewriters	No.	3,048	201,763
Scrap iron and steel.....	Cwt.	911,111	483,813
Hardware, viz. tools, etc.....			101,990
“ N.O.P.....			70,767
All other, N.O.P.....			1,051,004
Lime.....			29,234
Metals—			
Aluminium, in bars.....	Cwt.	130,150	1,762,214
“ manufactures of.....			8,203
Brass, old and scrap.....	Cwt.	32,144	293,572
Copper	“	24,972	324,903
Metallic shingles, etc.....			119,673
N.O.P.....			399,792
Mineral and aerated waters, in bottles.....			970
Naphtha and gasoline.....	Gals.	17,875	4,284
Oil, N.O.P.....	“	634,861	171,663
Plumbago, manufactures of.....			24,284
Stone, ornamental.....			7,381
Tar.....			30,628
Tin, manufactures of.....			53,783
Vehicles—			
Automobiles.....	No.	5,997	3,395,382
Automobile parts.....			210,623
Bicycles.....	No.	90	8,058
“ parts of.....			16,901
Total value of manufactures.....			20,730,707
“ products of the mine.....			58,073,167
Total exports.....			78,803,874

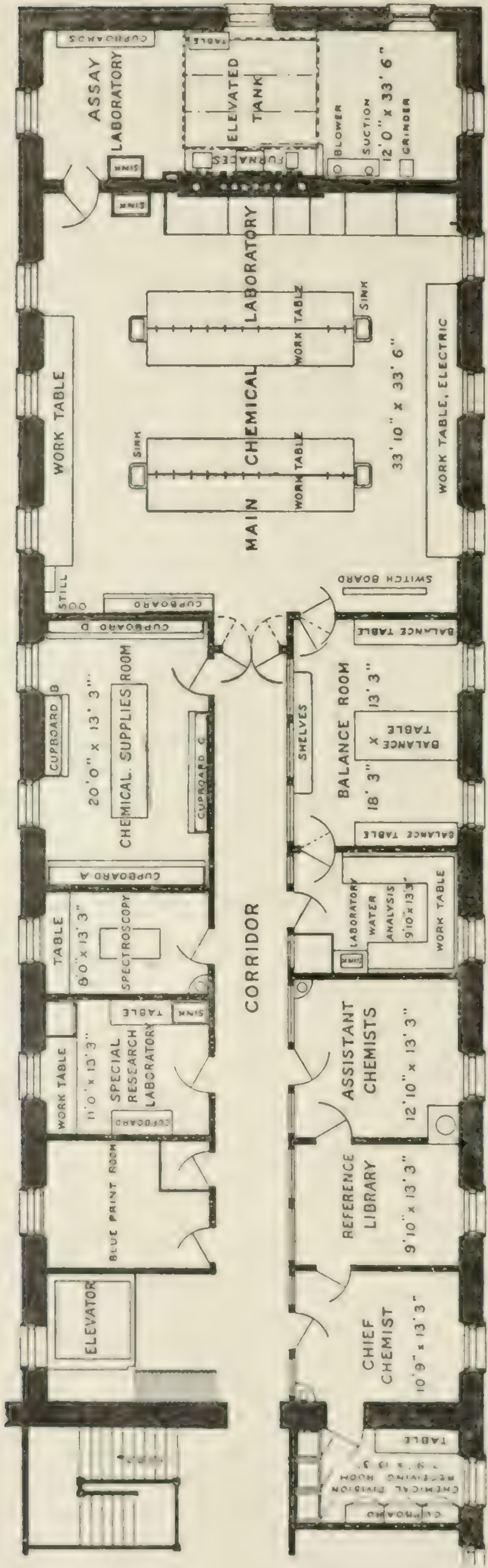


Fig. 17. Plan of Chemical Laboratories, Mines building, Sussex street, Ottawa.

APPENDIX II.

DESCRIPTION OF THE MINES BRANCH LABORATORIES.

THE CHEMICAL LABORATORY, SUSSEX STREET.

F. G. Wait.

On May 1, 1913, the chemical laboratory was transferred from its temporary quarters in the Thistle Chambers to that portion of the Mines Branch building—corner of Sussex and George streets—which has been set aside and remodelled for its accommodation.

In the alteration of what had long been known as the Geological Museum, the upper flat of the George St. wing of the building was set apart for re-arrangement, as a chemical laboratory, which would serve not only our present requirements, but would permit of considerable augmentation in the numbers of the chemical staff as might be required in the future.

A brief description of the plan and equipment may appropriately be given here.

The floor area—exclusive of corridor—of the space allotted to the laboratory is 2,961 square feet, divided into 11 rooms as follows:

Main laboratory.....	1,133 square feet.
Assay laboratory.....	402 "
Water analysis laboratory .. .	130 "
Special research laboratory .	146 "
Spectroscopy laboratory....	109 "
Balance room.....	242 "
Chemist's office .	142 "
Assistants' room.....	170 "
Chemical library.....	120 "
Room for storage of specimens awaiting analysis.....	102 "
Supplies room.....	265 "
	2,961 "

The arrangement of the several rooms is shown in the accompanying plan. (Figure 17.)

The Main Laboratory.

This has been planned with the object of providing a maximum of both light and ventilation. Three windows on either side, and four skylights—the latter equipped with the necessary shades—admit an abundance of daylight. Electric lighting is provided over each working space, on the tables.

Ventilation is secured by two electrically driven fans—one of six feet and another of two feet diameter. The larger is connected with the draught cupboards and the assay furnace hoods, and very effectively removes all evidence of vitiated air, while the smaller withdraws from the upper portion of the main laboratory over the work tables, and from the water analysis room and draught

cupboard. Fresh air is forced into this room, as well as all others in the building, from the ventilating system established in the basement.

The work tables, or benches (Plates XIII and XIV) are each sufficiently large to accommodate four men—two on either side. The four tubes, shown over the middle of each table, provide respectively, gas, exhaust, compressed air, and water. Each of these is tapped once in every three feet. An earthen drain pipe in the centre of each table and just below the surface makes provision for the waste from any piece of water cooled apparatus.

Electric current has been led to three plugs at either end of both centre tables.

The table tops are of teak wood.

The draught cupboards (Plate XV). This very important feature of any well-equipped laboratory is 24 feet in length by 2 feet 6 inches deep, and is sub-divided into six separate compartments,—four of 4 feet 6 inches and two of 3 feet each.

By means of sliding sashes, these may be connected by twos to form a single compartment, designed to accommodate a longer train of apparatus than a single unit would permit. Each compartment is supplied with taps for water, gas, compressed air and exhaust, and with plugs for electric connexion for heaters and other forms of apparatus.

Each compartment is ventilated separately and distinctly from each other. Direct connexion, by means of leaden conduits, with the larger exhaust fan, is made both from the top and the bottom of each sub-division. These openings, either top or bottom, may be regulated at the will of the operator. Each compartment is provided with a separate lighting, and with a waste water pipe. The floor and back wall are of white glazed tiles, the front, top and sides of plate glass.

Distilled water apparatus (Plate XVI). A Barnstead still, capable of furnishing from 8 to 10 gallons per hour, supplies distilled water for laboratory use, and the surplus is stored in a block tin-lined reservoir from which it is conveyed to a cooler in the basement, and thence to drinking fountains on the three floors of the office building, to supply the needs of the members of the staff in this respect.

ELECTRICAL EQUIPMENT.

Switchboard. (Plate XVII).

The laboratory is supplied with two switchboards, one for alternating, and one for direct current distribution.

The alternating current switchboard is equipped with the necessary switches for distributing the current to the different work tables and fume cupboards for hot plates, drying ovens, electric furnaces, small motors and lights. One voltmeter and two ammeters furnish readings of the current being used.

The direct current switchboard is used to distribute current to the work table devoted to electro chemical analysis.

The current is supplied by ten Edison storage cells, type B-6. The normal ampere hour output of these cells is 120 ampere hours, which is ample for the work they have to do.

For the purpose of charging the storage battery, a one K.W. motor-generator is used. The generator has a fifty per cent voltage regulation, 15 to 30 volts, which allows a charging current of almost any desired amperage to be used. An automatic cutout between the dynamo and the storage battery prevents a back discharge through the generator, should the alternating current be cut off at any time during a charge of the cells.

A 40 volt voltmeter and a 40-0-80 ampere ammeter give readings during charge or discharge of the battery.

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On the switchboard are four 11-point, semi-circular switches, one for each of the four outlets on the work table. Each switch is connected independently to the cells in such a manner as to allow the chemist to draw off current from one, two or any number of cells up to ten, at any one of the four outlets on the work table. The arrangement allows four different determinations, each one using a different voltage if necessary, to be made at the same time, or it will allow four chemists to use the battery independently at the same time.

The work table (also shown on Plate XIV) has a small distributing board for taking readings with portable laboratory voltmeters and ammeters, which are used in preference to switchboard instruments.

The Assay Room. (Plate XVIII).

In this room are placed the following appliances:—

- a. Melting and cupelling furnaces.
- b. Large muffle furnace, with a capacity of 10 fireclay crucibles.
- c. Oilshale distillation furnace.
- d. Exhaust.
- e. Air compressor.
- f. Agate mortar grinder.
- g. Anvils, mixing table and assay supplies cupboard.
- h. The larger ventilating fan.

Withdrawal of fumes from the several furnaces has been provided, by means of adjustable hoods, connected directly with the large ventilating fan, above referred to.

The main laboratory and the assay room have been made as nearly fireproof as the construction of a remodelled building would permit.

Water analysis laboratory. (Plate XIX).

This small laboratory has been designed, as its name indicates, to permit of this special type of analysis being carried on in a room free from the interference of ammoniacal or other deleterious vapours which are present in some measure in a general laboratory.

This room is supplied with water, gas and electricity, and a well-ventilated draught cupboard connected with the smaller of the two exhaust fans.

Special research laboratory. (Plates XIXA and XIXB).

This is a room, provided with work tables, gas, electricity, water, and draught cupboard, which has been set aside for the carrying on of any special line of research which is not likely to be of a permanent character. The figures in Plates Nos. XIXA and XIXB show this room as fitted up for experimental work on the bituminous sands of Alberta.

The balance room.

Plates XX and XXI show the general arrangement and the equipment of this room. Ten balances of various types are installed.

The spectroscope room. (Plate XXII).

When completely equipped, this room will be devoted entirely to spectroscopy as applied to the analysis of minerals and rocks.

Thus far, it has been supplied with:

- a. König's spectrophotometer.
- b. Browning's double prism reflecting spectroscope, and accessories.
- c. A direct vision spectroscope.

The electrical attachments have yet to be installed.

Such is a brief description of the present equipment of the laboratory. It is intended primarily to give the necessary attention to the samples collected by the field officers of the Geological Survey and Mines Branches; but, as has been the custom prevailing for many years, examinations, analyses or assays are made upon specimens sent to us by persons not members of our own staff.

For this latter class of work a nominal fee is charged, and certain conditions are imposed. The schedule of charges so made and the governing regulations are as follows:—

SCHEDULE OF CHARGES
(Revised, Dec. 1, 1911.)

Free chemical analyses and assays of metallic and non-metallic minerals have been discontinued, and the charges indicated in the following schedule were duly authorized on June 29, 1909.

Specimens will be dealt with in the order of their arrival: at such times as do not interfere with regular departmental research work.

TERMS:—Money in payment of fees—sent in by registered letter, Post Office Order, Postal Note, or Express Order, etc., and made payable to the Director of Mines—must invariably accompany the samples, as no examination will be commenced until the regulation fee is paid.

Specimens should be addressed as follows:—

To—
DIRECTOR OF MINES BRANCH,
DEPARTMENT OF MINES,
OTTAWA.

TARIFF OF FEES FOR ANALYSES AND ASSAYS.

1. ASSAYS:—

Gold.....	\$ 2 00
Silver.....	2 00
Platinum.....	4 00
Gold and silver in one sample.....	2 50
Gold and platinum in one sample.....	5 00
Gold, silver, and platinum in one sample.....	6 00
Iridium, palladium, and osmium—each.....	5 00

2. IRON ORES—

Determination of:—

i. Iron—metallic.....	2 00
ii. Iron, and insoluble residue.....	2 50
iii. Ferrous oxide.....	3 00
iv. Sulphur.....	2 00
v. Phosphorus.....	3 00
vi. Titanium.....	3 00
vii. Iron, sulphur, phosphorus, and insoluble matter.....	5 00
viii. Manganese.....	2 00
ix. Complete analysis—determination of ferrous oxide, ferric oxide, total metallic iron, silica, manganese, alumina, lime, magnesia, sulphur, phosphorus, titanium, water.....	20 00

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3. LIMESTONES, DOLOMITES, AND MARLS—

Determination of:—

i. Insoluble matter, oxide of iron and alumina together, lime, and magnesia.....	5 00
ii. Insoluble residue and magnesia (qualitative test only)	1 50
iii. Insoluble residue and magnesia (quantitative determination).....	3 50
iv. Phosphoric anhydride.....	3 00
v. Carbonic anhydride (carbonic acid gas).....	3 00

4. CLAY, CLAY SHALE, AND CEMENT STONE:—

i. Qualitative examination of clay as to its adaptability for manufacture of porcelain, bricks, and refractory ware.....	2 00
ii. Examination of clay, shale, or cement stone, for cement manufacture—determination of silica, iron oxide, alumina, lime, magnesia, and volatile matter.....	10 00
iii. Complete analysis of clay, shale, etc., including determination of:—silica, free and combined, ferric oxide, ferrous oxide, alumina, lime, magnesia, titanitic oxide, carbonic anhydride, carbon, sulphur, and combined water.....	25 00

5. COALS, LIGNITES, AND COKE—

Determination of:—

i. Water, volatile matter, fixed carbon, and ash.....	5 00
ii. Sulphur.....	2 00
iii. Phosphorus.....	3 00
iv. Calorific value.....	5 00
v. Ultimate analysis—determination of carbon, hydrogen, oxygen, nitrogen, and sulphur.....	25 00

6. MINERAL WATERS:—

i. Qualitative examination—giving amount of saline matter per gallon, and a general idea of the chemical nature of its constituents.....	\$ 3 00
ii. Quantitative analysis.....	25 00 and upwards
according to number of constituents determined.	

7. ORES AND MINERALS—

Determination of:—

i. Alumina.....	\$3 00
ii. Antimony.....	3 00
iii. Bismuth.....	3 00
iv. Carbonic anhydride.....	3 00
v. Chromium.....	3 00
vi. Cobalt.....	4 00
vii. Copper.....	2 00
viii. Ferrous oxide.....	3 00
ix. Ferric oxide.....	2 00
x. Lead.....	3 00
xi. Lime.....	2 00
xii. Magnesia.....	3 00

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xiii.	Manganese.....	3 00
xiv.	Nickel.....	4 00
xv.	Silica.....	3 00
xvi.	Water—combined.....	3 00
xvii.	Zinc.....	3 00
	Non-metallic minerals: asbestos, gypsum, etc., complete analysis of.....	Prices on application.
8.	ROCKS—complete analysis.....	Prices on application.
9.	METALS AND ALLOYS—	
	Determination of:—	
i.	Aluminium.....	\$ 3 00
ii.	Antimony.....	3 00
iii.	Arsenic.....	3 00
iv.	Bismuth.....	3 00
v.	Cadmium.....	3 00
vi.	Chromium.....	3 00
vii.	Cobalt.....	4 00
viii.	Copper.....	3 00
ix.	Gold.....	2 00
x.	Iridium.....	5 00
xi.	Iron.....	2 00
xii.	Lead.....	3 00
xiii.	Manganese.....	3 00
xiv.	Mercury.....	5 00
xv.	Molybdenum.....	5 00
xvi.	Nickel.....	4 00
xvii.	Osmium.....	5 00
xviii.	Palladium.....	5 00
xix.	Phosphorus.....	3 00
xx.	Platinum.....	4 00
xxi.	Silicon.....	3 00
xxii.	Silver.....	2 00
xxiii.	Sulphur.....	2 00
xxiv.	Tellurium.....	5 00
xxv.	Tin.....	4 00
xxvi.	Titanium.....	3 00
xxvii.	Tungsten.....	3 00
xxviii.	Vanadium.....	5 00
xxix.	Zinc.....	2 00
10.	IRON AND STEEL—	
	Determination of:—	
i.	Total carbon.....	5 00
ii.	Graphite.....	3 00
iii.	Combined carbon.....	2 00
iv.	Sulphur.....	2 00
v.	Phosphorus.....	3 00
vi.	Silicon.....	2 00
vii.	Manganese.....	1 00
11.	FERRO-ALLOYS.	
	Ferro-silicon, Ferro-chromium, Ferro-manganese, and Ferro-titanium—	
	Determination of:—	
i.	Silicon, sulphur, phosphorus, manganese, chromium, titanium, each.....	3 00

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12. SLAGS AND FIRE-SANDS—

Determination of:—

- i. Silica, iron oxide, alumina, lime, magnesia, and loss
on ignition..... 10 00
- ii. Complete analysis..... 15 00

13. GAS ANALYSIS.....Prices on application.

14. OIL-SHALES—

Determination of:—

- i. Crude oil content..... 4 00
- ii. Ammonium sulphate..... 6 00

15. Identification of minerals and rocks not requiring chemical
analysis..... Free.

DIRECTIONS.

ORES.

For analysis it is necessary that the sample sent in should weigh from 2 to 5 pounds; and consist of a number of small fragments rather than one large piece.

MINERAL WATERS.

Sample waters should be sent in clean, stoppered, glass bottles, containing, at least, one-half gallon for qualitative, and two gallons for quantitative examination. The bottle must be well rinsed with the same water as the sample itself, and have a label attached stating whether the respective samples are from a boring, spring, or stream.

LOCALITY.

In every instance, specimens and samples should be accompanied by a statement specifying the precise locality from whence they were taken.

RECORD OF WORK DONE.

With the exception of about four weeks—which time was occupied in removing from the Thistle Building and in getting settled in the new premises—the laboratory has been in operation throughout the year. Messrs. M.F. Connor, B.A. Sc., Mr. H. A. Leverin, Ch.E., and Mr. N. L. Turner, M.A., have applied themselves with commendable diligence to the tasks in hand and much good work has been accomplished.

During the year 610 specimens have been examined and reported upon. The work has been of the usual varied character, and for purposes of this Summary Report, may be classified, alphabetically, as follows:

Assays.

During the year 178 samples have been subjected to furnace assay, to ascertain the extent of their richness in gold and silver, and, in a few instances, the metals of the platinum group.

By Provinces these may be classified as follows:—

New Brunswick.....	5
Quebec.....	17
Ontario.....	35
Manitoba.....	5
Alberta.....	1
British Columbia.....	38
Yukon Territory.....	65

and in addition 13—the locality of occurrence of which was not divulged by the sender.

None of these are deserving of special mention in this Summary Report.

Alunite-bearing rock.

None of these are deserving of special mention in this Summary Report.

One sample of partially altered felspathic rock—in which it was thought that alunite might be present—from the shores of Kyoquot sound, Vancouver island, has been examined during the year.

Alunite is a hydrous sulphate of aluminium and potassium with the following composition: sulphur trioxide, 38·6, alumina, 37·0, potash, 11·4 and water 13·0, = 100.

Dana says of it—'Forms seams in trachyte and allied rocks, where it has been formed as a result of the alteration of the rock by means of sulphurous vapours.'

It might be regarded as a source of potassium.

It is slowly soluble in hot water, and readily so in hot acidulated water. The sample examined was found to contain but a trace of the mineral in question.

Building Stones.

Fourteen samples, from as many different localities in Quebec, collected by Dr. W. A. Parks, in connexion with his investigation of building stones, have been submitted to examination, as desired by him. Of these, eight were limestones, and were fully analysed. Of those remaining, five were sandstones, and were examined with a view to determining (1) the percentage of ferrous and ferric oxides present as an index of their behaviour on weathering, and (2) the nature of their cementing material.

Clays.

Some twenty-two samples of clay have been sent in for examination during 1913.

Many of these were thought by the parties sending them to be suitable for use as fireclays, whilst others were intended for use in cement manufacture, and others in brick and tile making. So far as our limited appliances would permit, these have been qualitatively examined, and the results communicated to the proper persons. Of those examined, four samples were from Alberta, three from Saskatchewan, four from Quebec and three from New Brunswick, five from the property of the Peerless Brick Co., on north half of lot 20 in Junction Gore, Rideau Front, Nepean township, Carleton county, Ont. The seven remaining were not accompanied by any particulars of locality of occurrence.

Clay Iron Stone.

Two samples of this iron 'ore' have been sent from Alberta. As this material is situated within reasonable distance of the extensive coal deposits of the western provinces, it is worthy of investigation. Samples from several localities have been sent in from time to time in years past, and it would appear that its distribution is somewhat widespread.

Copper Ores.

Eighty-seven samples of copper ores, or of copper ore concentrates, have been analyzed during the year. Of these 67 were from the ore concentration plant of this Branch, and particulars regarding them will no doubt be dealt with in the report of the officer in charge of that division.

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Of the remaining samples, fourteen were from Valdez island, B.C., one from lot 5, con. V of Baldwin township, Algoma district, Ont.; the remaining five samples were not accompanied by any information as to their precise locality of occurrence.

Coals and Lignites.

Two samples of lignite from the Peace River district—exact location not specified—and five of coal and one of anthracite coal from Queen Charlotte islands—these latter collected by Mr. J. D. Mackenzie of the Geological Survey—have been submitted to proximate analysis.

Cobalt Ore.

Two samples from Miller lake, Nicol township, Nipissing district, Ontario, have been sent for analysis. One was found to contain approximately 9 per cent of this metal, while the second was barren.

Iron Ores and Iron Ore Concentrates,—in all 57 samples.

There has been an increase in the number of specimens under the heading examined during 1913.

The following list shows the character of the ore or concentrate, and, so far as known, the locality of their occurrence.

Magnetite:—

- (a) Nova Scotia—one sample from McPherson's mine at or near Barrachois, Cape Breton county.
- (b) Quebec—one sample from unsurveyed territory in the northern part of Pontiac county.
- (c) Ontario—Moose Mountain ore—3 samples from as many different points on lots 11 and 12, concessions IV and V, of the township of Hutton, Nipissing district.

“Flower station ores”—18 samples of concentrates, prepared at the ore concentrating plant, from ores at Flower station, K. and P. Ry., in Lavan township, Lanark county.

Two samples from lot 29, con. VI, of Bagot, Renfrew county.

- (d) British Columbia—6 samples from the undermentioned points on Texada island: Iron Range (2), Prescott mine (2), Paxton mine (1), Lake mine (1).

*Hematite:—*A single sample from Upper Glencoe, Inverness county, N. S.

In addition to the foregoing there were 21 samples of concentrates from the Hudson Bay mine, at Salmo, B.C., consisting of an admixture of limonite with calamine (zinc silicate) which were partially analyzed to ascertain their content of zinc and iron.

The remaining four samples were not accompanied with sufficient particulars of locality to be specially mentioned here.

Limestones.

During the year eight samples of limestone have been analyzed, but none are worthy of special or extended notice here. One sample was taken at Pocahontas, three from Banff, all in Alberta, and four from British Columbia. The information accompanying those from British Columbia showed them to have been taken from Blubber bay (2) and Stuart bay (1)—Texada island, and a single sample from the Lynthrope quarries at Kamloops.

Eight limestones, examined to ascertain their fitness for use in building operations, are referred to under Building Stones.

Lead Ores.

Three samples of galena concentrates, prepared from the mixed sulphite ores of Calumet island, Quebec, have been received and reported upon, as well as a single sample from an 18-foot lead on Adams' claim at Rainy Hollow, B.C.

*Marl, under "Miscellaneous."**Molybdenite.*

Two samples of molybdenite bearing rock, from lots 1 and 2, range III of Aldfield township, Pontiac county, Quebec, one from lot 16, con. XI of Brougham, Renfrew county, and 22 samples of concentrates prepared from material taken on lot 8 of con. XI of the same township, in Renfrew county, Ontario, have been reported upon.

Miscellaneous Materials.

In this group is placed a wide variety of materials which have been sent in during the year. Of the 170 samples so disposed of, 145 were sent for purposes of identification only, whilst the remaining 25 were submitted to a partial analysis.

Nickel Ores.

Of the five supposedly nickeliferous ores which were examined during the year, four originated in Ontario and one in British Columbia. None were found to contain nickel in paying quantities.

Oil Shales.

Fifteen samples from Albert Mines, Albert county, N.B., and one from Duck Mountain, Man., have been examined.

Rocks and Mineral.

The analyses of eleven rocks and one mineral have been completed and reported, and the analytical work upon several others has been entered upon.

Tin and Tungsten.

Six samples of country rock, which it was thought might carry appreciable quantities of these metals, have been examined, but with negative results in all cases. All were from the New Ross area in Lunenburg county, Nova Scotia.

Waters.

Two samples of supposed mineral waters have been analyzed. One was from a spring on the property of Mr. Louis Daoust, situated on lot (?), con. I, of Alfred township, Prescott county. The second sample was from a boring, said to be 1000 feet deep, at Webster's Corners, township 12, New Westminster, B.C. The quantity of the latter sample which was submitted to me was altogether inadequate for a satisfactory examination to be made upon it.

SESSIONAL PAPER No. 26a

DESCRIPTION OF FUEL TESTING STATION AND LABORATORIES.

B. F. Haanel.

With a view to classifying the various coals of Canada, and to ascertain the most efficient methods for their preparation for the market, and their utilization for the various purposes of the arts and industries, an investigation was undertaken about eight years ago, by the engineering staff of the University of McGill, under the auspices of the Mines Branch, Department of Mines. The published reports, embodying the results of this special work, are entitled—"An investigation of the Coals of Canada." Prior to the completion of this work, begun at McGill University, the Mines Branch established at Ottawa, in 1909, an experimental station primarily intended for the examination and testing of low grade fuels; but the scope of the work of this experimental station was subsequently extended to include all fuels—solid, liquid, and gaseous—met with in Canada. This extension of the field of investigation necessitated the reconstruction and enlargement of the Fuel Testing Station, and the addition of complete chemical laboratories. The work of modifying the existing plant to meet the new conditions was begun about three years ago, and completed within the last twelve months.

The Fuel Testing Station is at present equipped for the complete investigation of the fuels of Canada, along the following lines: (1) their chemical examination, including the determination of heating value; (2) the distillation of petroleum and bituminous coals, such as lignites, for the purpose of ascertaining their value for the recovery of various oils, and (3) the investigation, on a commercial scale, of the value of the various coals for the generation of gas when burned in a producer, and for the generation of steam. Inasmuch as many of the lignites of the western Provinces cannot be advantageously utilized for the production of power through the media of steam boilers and steam engines, but are particularly well adapted for the production of power through the media of a gas producer and gas engine, the latter phase of the investigation will prove of direct and immediate value to those Provinces.

Chemical Laboratories.

These laboratories are well equipped to carry out all kinds of fuel analyses, and also for research work on fuels. Equipment has also been provided for the making of all the analyses required by the Ore Concentrating and Metallurgical Division.

There are at present six rooms in the laboratories, and a seventh room is now being equipped to accommodate the bomb calorimeters.

The Balance Room and Office is shown in Plate No. XXIII. In this room there are desks for the principal chemists, bookcases for works of reference, racks for current chemical literature, and a number of different types of balances. The balances are on a slate slab supported on iron girders and pillars, rising from a large concrete pier which stands on a rock foundation, and isolated from the walls of the building.

In the general laboratories, determinations of moisture, sulphur, volatile matter, and nitrogen are carried out. Extraction and distillation tests of coals, oil sands, oils, etc., and other miscellaneous tests, are also made here. The bench shown in Plate XXIV is reserved for the work of the Ore Concentrating and Metallurgical Division.

Plate XXV is a photograph of one end of the furnace room, shows an electrical combustion furnace and gas furnace, with all accessories necessary for the determination of the carbon and hydrogen in fuels; also an electric muffle furnace for the determination of ash, etc. The furnace room also contains an electrically heated tar still, an autoclave, an optical pyrometer, a gas muffle furnace, and fire assay equipment.

Plates Nos. XXVI and XXVII show interior views of the gas analysis and calorimetry room. Plate XXVIII shows the bomb calorimeter bench, with calorimeters for determining the heating value of fuels, and an electrical resistance thermometer capable of reading 0.001°C .

Plate XXVII shows the gas analysis bench. Three complete gas analysis apparatus are here set up, also an apparatus for directly determining nitrogen in gas, an electric signal clock, and a standard barometer.

Plate XXVIII shows the gas calorimeter bench where determinations of the heating value and of tar content of gas are made. Two calorimeters, and one of tar determination apparatus are shown, together with the necessary pressure regulators and meters. Producer gas from the producer room and flue gas from the boiler room are brought to this bench in suitable pipes. A sampling pump and motor are shown on the right, and a mercury gas sampling device on the left, by means of which gas is supplied to the calorimeters, etc., and average samples of gas automatically taken over definite periods for analysis. A mercury still is also shown in the photograph.

Plate XXIX shows several forms of standard apparatus for the determination of the colour, flash point, viscosity, and refractive index of oils. The laboratory is also equipped with apparatus for determining the lubricating value, sulphur content, and specific gravity of oils, and with a standard apparatus for distillation tests, but these are not shown in the photograph.

The sampling room is equipped with crushing and grinding machinery for the preparation of samples of coal and ashes, etc., and samples are stored here for a year or more after analysis, in case any question concerning them should arise.

The storeroom is provided with suitable cupboards and drawers for stores of chemicals and apparatus.

Machine Shop.

In order to facilitate the work of the Fuel Testing and Ore Dressing and Metallurgical Division—which from time to time involves considerable original and research work, a machine shop has been provided. The equipment includes a Brown and Sharpe universal milling machine; Pratt and Whitney engine lathe; Stockbridge shaper; Brown and Sharpe universal grinding machine; one precision drill, and one drill press. All of the machines are operated by individual motors attached to the machines.

The complete equipment of this machine shop enables these divisions to rapidly construct special pieces of apparatus or to repair those already in existence.

Power Plant.

The power plant consists of a 60 B.H.P. Korting, 4 cycle, gas engine, direct connected to a Westinghouse 50 K.W., D.C. generator. The current generated is led to a switchboard from which it is delivered to the desired points. From this switchboard the alternating current, led into the building from the street lines, is also distributed to the various parts of the Fuel Testing Station and Concentrating Laboratory.

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Testing Laboratory.

The Testing Laboratory is equipped with a Westinghouse double zone bituminous suction gas producer of 125 horse power capacity, including an exhaustor, gas washer, gas receiver and gas regulator. This producer is used for determining the value of bituminous coals and lignites for the production of gas for power or other industrial purposes. A Korting, double zone suction gas producer of 60 B.H.P. capacity, is installed for determining the value of the various peats for the production of a gas. The latter producer is exhausted by means of the gas engine.

For the purpose of measuring the quantities of gas produced, a rotary meter is employed. Between this meter and the gas engine an anti-pulsator is interposed, in order that the volume of gas produced can be accurately measured when the engine is in operation.

The temperatures in various portions of the producers are measured by means of pyrometers, the recording and indicating mechanisms of which are fixed on a suitable wall board. On this board are also attached a Smith recording gas calorimeter, and the various water manometers for recording the suctions or pressures in various portions of the producers and cleaning systems.

A *Babcock and Wilcox Marine Water Tube Boiler* is used for determining the value of the various fuels for steam raising. This boiler is encased in steel, thus reducing air leakage to a minimum. A plate fan built by the Canadian Sirocco Company is used for exhausting the products of combustion. The boiler room is equipped with the necessary feed water pumps and weighing tanks.

The equipment described serves the purpose of determining the relative values of fuels for the production of power when burned in a gas producer, or under a steam boiler.

The accompanying plates and figures illustrate the several laboratories, apparatus, testing plant, and the manner in which they are placed in the building.

During the last two years, the Mines Branch has been collecting both mine and commercial samples of coal for purposes of testing and chemical examination at the fuel testing station. These samples are supplied to the Department, by the producers, free of charge; the Department paying the freight charges only. Such commercial samples as are obtained by the officials of the Mines Branch are carried by the railways, from the mines to Ottawa, at a special tariff.

Any mine operator desiring to have his coal tested on a commercial scale—independently of the investigations now being conducted—with a view to determining its value for power or other purposes, can do so by sending to Ottawa a commercial sample of not less than 15 tons, all charges prepaid; providing arrangements have been made, previously, for the accommodation of such sample. Independent work of this character will be undertaken only at such times when the laboratories are not engaged on the routine work of the Department.

SESSIONAL PAPER No. 26a

THE ORE DRESSING AND METALLURGICAL LABORATORIES.

W. B. Timm.

General approval of the work carried on by this Division has been expressed by the mining public. The tests conducted on magnetic iron ores have met with favour and appreciation by men engaged in the iron and steel industry. The scarcity in the domestic supply of high grade iron ore, and the extensive, undeveloped deposits of low grade ore are becoming important factors in the iron industry. By concentration of our lower grade ores and by the elimination of impurities such as sulphur, phosphorus, and titanium, to small percentages, it is hoped that the poorer iron ore deposits will become profitable sources of supply.

In the last few years the mining industry of Canada has become an important one. New fields have been discovered and opened up, which have placed it the second industry of importance in the Dominion. In order to promote the industry, the need of a testing laboratory, equipped with modern machinery and apparatus, possessing sufficient latitude and elasticity to cope with the more general demands of the mineral industry, was apparent. In such a laboratory test work and research investigation should be carried on in connexion with the dressing and metallurgical treatment of the various Canadian ores.

The old laboratory consisted of a small room at the Fuel Testing Station, in which the machinery installed was so crowded that the addition of more apparatus was impossible. It was, therefore, decided to make a substantial addition to the Fuel Testing Station, to provide for the equipment of the new laboratory.

The new addition has a floor area of 57×75 feet, and is one storey and one-half high. The Testing Laboratory has a floor space of 57×57 feet. The remaining portion of the addition is used for machine shop, warehouse, and chemical laboratories.

In June, 1912, work was commenced on the construction of the new addition. Building operations continued until the latter end of November, hence it was not until December that the installation of machinery could be started.

Design of the Plant.

In designing the plant, care has been taken to place the machines so that ore dressing combinations can easily be made, with as little handling of the ore as possible. Actual mill conditions are, therefore, duplicated to a large extent.

What the proper combination should be and the best mode of treatment is predetermined by preliminary tests made on laboratory type machines. After having arrived at the most suitable flow sheet, the large machinery is adjusted for this combination.

The large scale machinery and apparatus are placed on the ground floor, which is of concrete, and through which channels run to carry the overflow water to three large concrete sumps, below the floor, connected with the drain from the building. The feeders to the machines and the laboratory type apparatus are placed on the second floor.

Equipment of the Plant.

The plant is equipped with laboratory size apparatus, and the ordinary size machinery and apparatus used in actual practice. With the laboratory type apparatus small scale and preliminary tests are conducted; with the large scale apparatus and machinery the large scale tests are made; after first determining the best mode of procedure by preliminary tests with the laboratory machines.

LABORATORY TYPE APPARATUS.

Crushing and Grinding.

The crushing machinery is placed on a table covered with $\frac{1}{4}$ " steel plate firmly bolted to the table. The crushed material is caught in drawers in the table. The machinery consists of:

One 2"×6" Sturtevant laboratory jaw crusher.

One 8"×5" Sturtevant laboratory rolls.

Small shipments up to 600 pounds are crushed in these machines, which are also used in preparing the samples for analysis.

The grinding apparatus consists of:—

One Braun planetary pulverizer.

One six-jar Abbe pebble mill.

The *pulverizer* is placed on the crushing table and the pebble mill on the wall behind the pulverizer. They are used for grinding down the samples and preparing them for analysis.

Sizing and Screening.

The sizing and screening apparatus is as follows:—

One gyratory screen frame of the Hoover type.

One Sturtevant box screen.

One complete set of I.M.M. standard screens.

One complete set of Tyler standard screens, after Rittinger scale.

One complete set of Sturtevant screens.

The *gyratory screen frame* of the Hoover type is for the purpose of making sizing tests on the crushed ore and for screen analysis. The nested screens are placed in the frame. A sample of the crushed material is taken and put in the top screen. By the gyratory motion of the frame, the material is sized on the various screens. The screens are removed from the frame, the various sized products weighed, percentages calculated and samples taken for analysis. The Tyler standard or the I.M.M. standard screens are used in this machine.

The Sturtevant box screen is used in connexion with the small scale or preliminary tests for obtaining sized products. It consists of a box in which the screen is placed at a small angle with the horizontal. The screen is given shaking motion by a bumping arrangement driven from the main line shaft, the crushed ore is fed to a hopper, the feed being adjusted by an eccentric on the feeder arm. The oversize passes over the screen and the fines are caught in a drawer in the box below the screen. The product through the screen is removed from the drawer and run over the next size screen. Sturtevant screens are used in this machine.

Sampling.

The sampling is done in two sets of Jones riffled samplers. The coarser set is used for the coarser and larger cuts of the sample, the finer set for the finer and last cuts made of the sample.

PLATE XXXIX.



Ore dressing laboratory: sizing apparatus, second floor.

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Classification and Concentration.

The classifiers consist of:—

One tube classifier.

One Richards laboratory classifier.

The *tube classifier* is simply a 1" glass tube, drawn out at one end, first to $\frac{1}{2}$ " and to $\frac{3}{8}$ " at the end. The 1" portion is 18" long, graduating into the $\frac{1}{2}$ " portion to which is a $\frac{1}{2}$ " intake at right angles with the tube. A galvanized iron cone is connected with the tube by rubber hose at the top, to which the material to be classified is fed to the tube. In one side of the cone is an opening to carry off the overflow water and slimes. The bottom of the tube is connected with a glass flask by a rubber hose and the water intake is connected by a rubber hose to a pulsating valve operated by hand which in turn is connected with the water line. The classifier is set at a convenient location on the wall and is used to determine whether an ore is adaptable to classification and concentration.

The *Richards laboratory classifier* has a single compartment three-inch square sorting column, and is equipped with a glass side for viewing the classification that is taking place, and a pulsating valve driven by a friction drive for changing the speed of the valve. Two spigots in the sorting column permit a classification of four products. The heavier product is drawn off by a spigot at the bottom of the column, the lighter product with the overflow, and two intermediate products if desired from the two spigots in the sorting column. The water for classification is supplied from two tanks placed at elevations above the classifier to give the desired head. Attached to the water line is an air chamber, set over the pulsator valve, for the purpose of intensifying the pulsations as well as preventing water hammer in the supply pipe. The classifier is set on a table, covered with $\frac{1}{4}$ " steel plate. The ore to be classified is fed automatically from a small feeder. The feed is adjusted by lowering or raising the slide on the feeder and by speed cones on the feeder and counter shaft.

The concentrating apparatus consists of:—

One laboratory Richards jig.

One 24" laboratory Wilfley table.

The *laboratory Richards jig* is a three-inch, single-compartment, pulsating jig, equipped with tube discharge, glass side for viewing the jigging action and friction drive for changing the speed of the pulsator valve. The sorting column of the classifier and the jigging column of the jig are interchangeable. Both classifier and jig are set on the same frame, the same feeding device and pulsating action are used in both. The material fed to the jig is subjected to the jigging action of the upward pulsating current, the heavier particles of mineral settling to the screen and accumulating there pass under the seal and out the concentrates discharge gate. The seal allows only the heavier material down on the screen to pass to the discharge gate because the lighter material which must necessarily ride on the top of the heavy material, cannot get down to the bottom of the seal to pass under it. The seal is a semi-circular piece of light iron attached to the concentrate discharge side of the compartment and can be raised or lowered to suit the material to be jigged. The concentrate discharge gate is also adjustable and can be raised and lowered to suit the jigging action which is visible through the glass side of the jig.

The *laboratory 24" Wilfley table* is placed on a table covered with $\frac{1}{4}$ " steel plate. The material to be concentrated is fed to the table by an automatic feeder driven from the counter shaft. The feed is regulated by the feeder gate and by cone pulleys on the feeder eccentric shaft and on the counter shaft. The table is adjusted to suit the material to be concentrated by raising or lowering the slope of the table, by changing the stroke, and by increasing or decreasing

the speed by the cone pulleys on the eccentric shaft and counter shaft. Four products can be obtained if desired. The overflow from the product boxes run into a tank under the table top in which any overflow slime from the product boxes is collected. The overflow from the tank is carried by a hose into the sump tanks below the lower floor. The tank can readily be pulled out and cleaned.

Magnetic Separation.

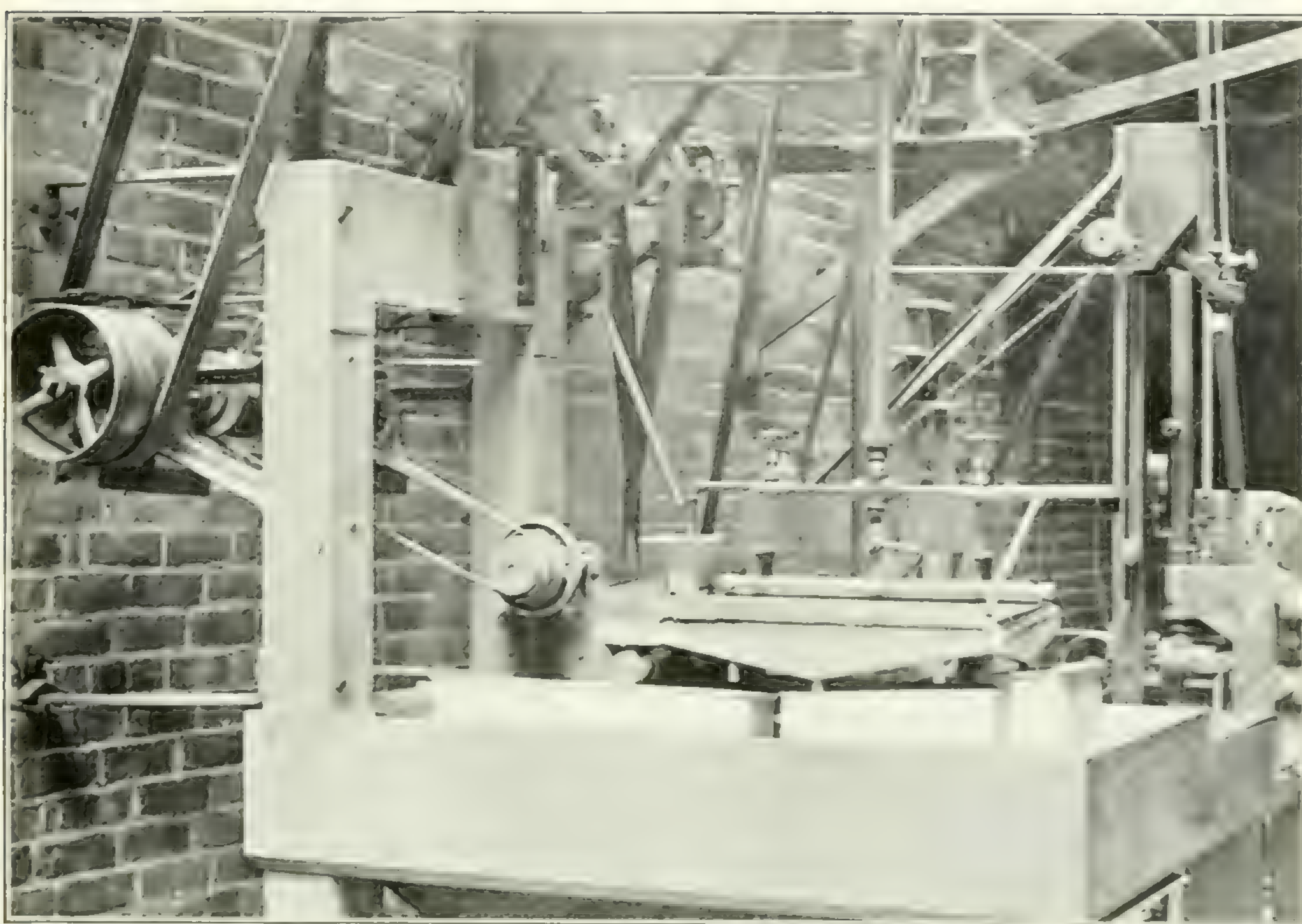
The magnetic separators consist of:—

One laboratory Grondal dry separator.

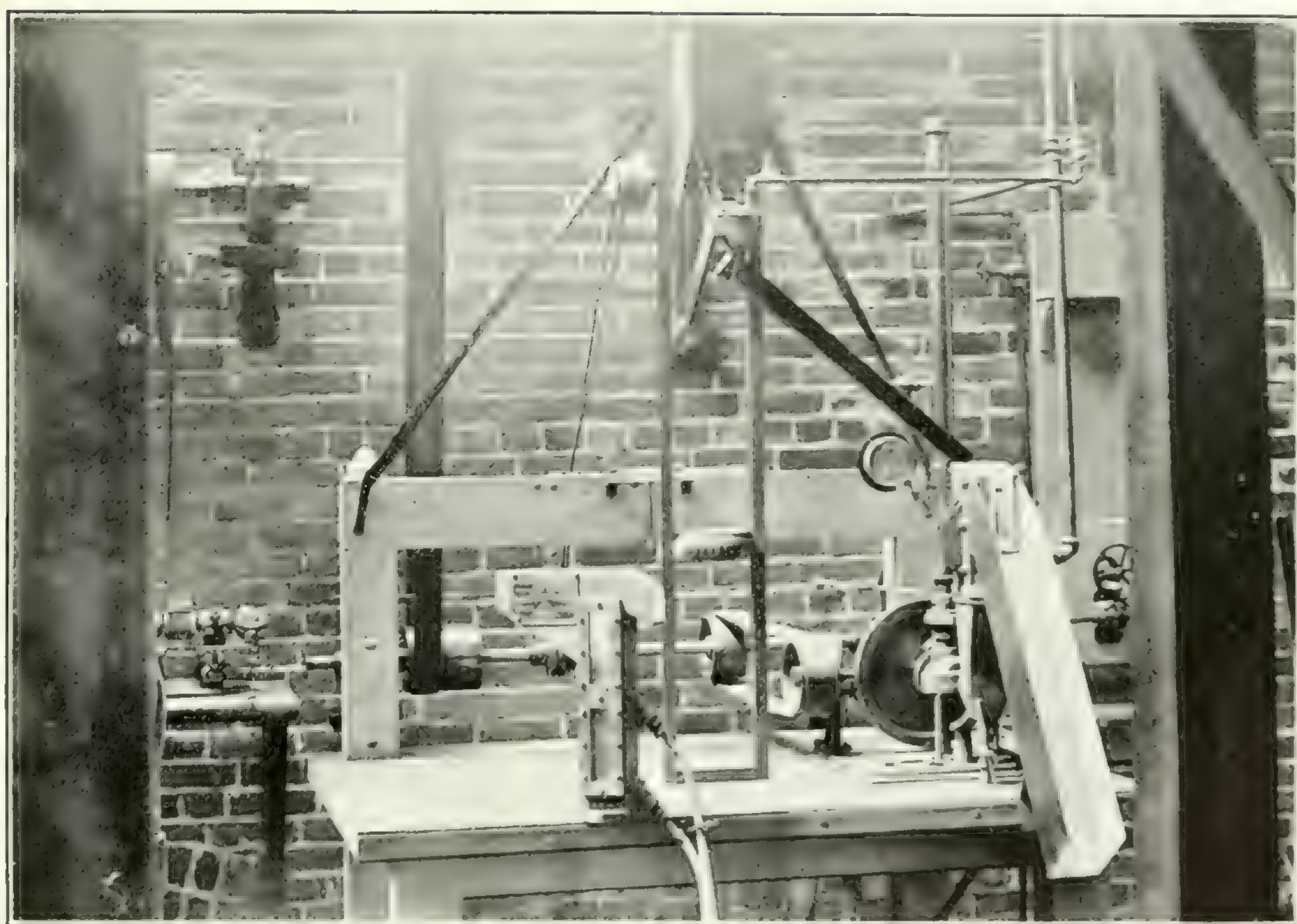
One laboratory Grondal wet separator.

The upper and pole portion of these two machines is interchangeable. It consists of two sets of four magnets each, suspended in a frame between two pulleys around which an endless belt travels. In the dry separator, the first set of magnets is used as rectifying magnets, the separation being made by the other set nearer the discharge end. The lower portion of the machine consists of a frame in which are set two pulleys, around which an endless belt travels. The ore is fed unto the lower belt from an automatic feeder. The feed is regulated by the feeder gate and by speed cones on the feeder eccentric shaft, and on the line shaft. Both belts travel in the same direction and are spaced about $\frac{1}{2}$ " apart. The material fed on the lower belt travels along with it until it reaches the first set of magnets; the magnetic particles are here rectified and made more susceptible to the influence of the second set of magnets. Travelling with the belt, the feed comes under the influence of the latter set, the magnetic particles are drawn up and clinging to the upper belt are dropped as soon as they are passed out of the magnetic field, into a chute to a pail or tub placed under the table. The non-magnetic particles travel with the lower belt and are dropped through a chute to a pail or tub under the table. The separation depends on the strength of the magnetic field which is regulated by a rheostat on the switch board, the feed adjusted by the feeder gate and speed cones, the rate of travel of the feed, which can be increased or decreased by moving the belt on the cone pulleys, the distance of the feed travelling along the lower belt from the magnets which can be raised or lowered and the position of a hinged vane separating the magnetic from the non-magnetic discharge. The separator is placed on a table covered with $\frac{1}{4}$ " steel plate.

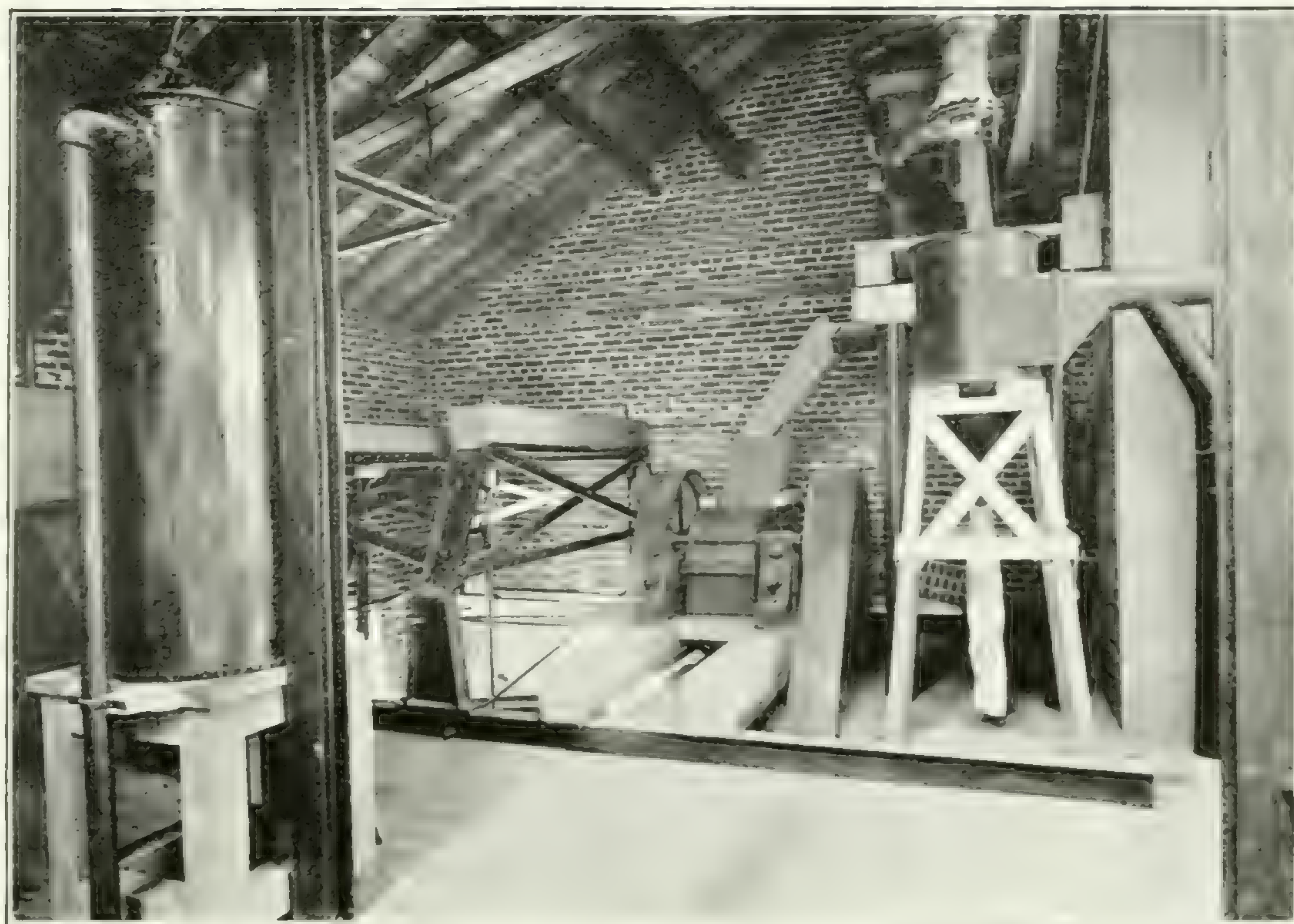
The lower portion of the wet separator consists of a brass box, divided into compartments, and is equipped with glass sides for viewing the separation being made. The upper portion described above, is placed on the box. The ore is fed to the machine by an automatic feeder into the first compartment. A head of water entering this compartment from below keeps the ore in suspension. In flowing over a weir, it comes under the influence of the first set of magnets, the magnetic particles are carried to the take off belt, by the magnets, while the non-magnetic particles are deposited in a second compartment. In their course towards the discharge end the magnetic particles are carried over to a third compartment which has a slightly raised weir, preventing the weakly magnetic particles held in suspension from passing over the weir. They settle in the third compartment. The stronger magnetic particles are carried on until they pass from the influence of the magnets and are dropped into a fourth compartment against a head of hydraulic water and are reconcentrated by the next set of magnets in a similar manner. Clean concentrates are discharged from the box. Concentrates clinging to the belt are washed off by a spray of water into the discharge compartment. The various products are drawn off into pails set in a tray below the table on which the separator is placed. The overflow water from the tray runs through a hose into the sump tank below the ground



Ore dressing laboratory: Wilfley table.

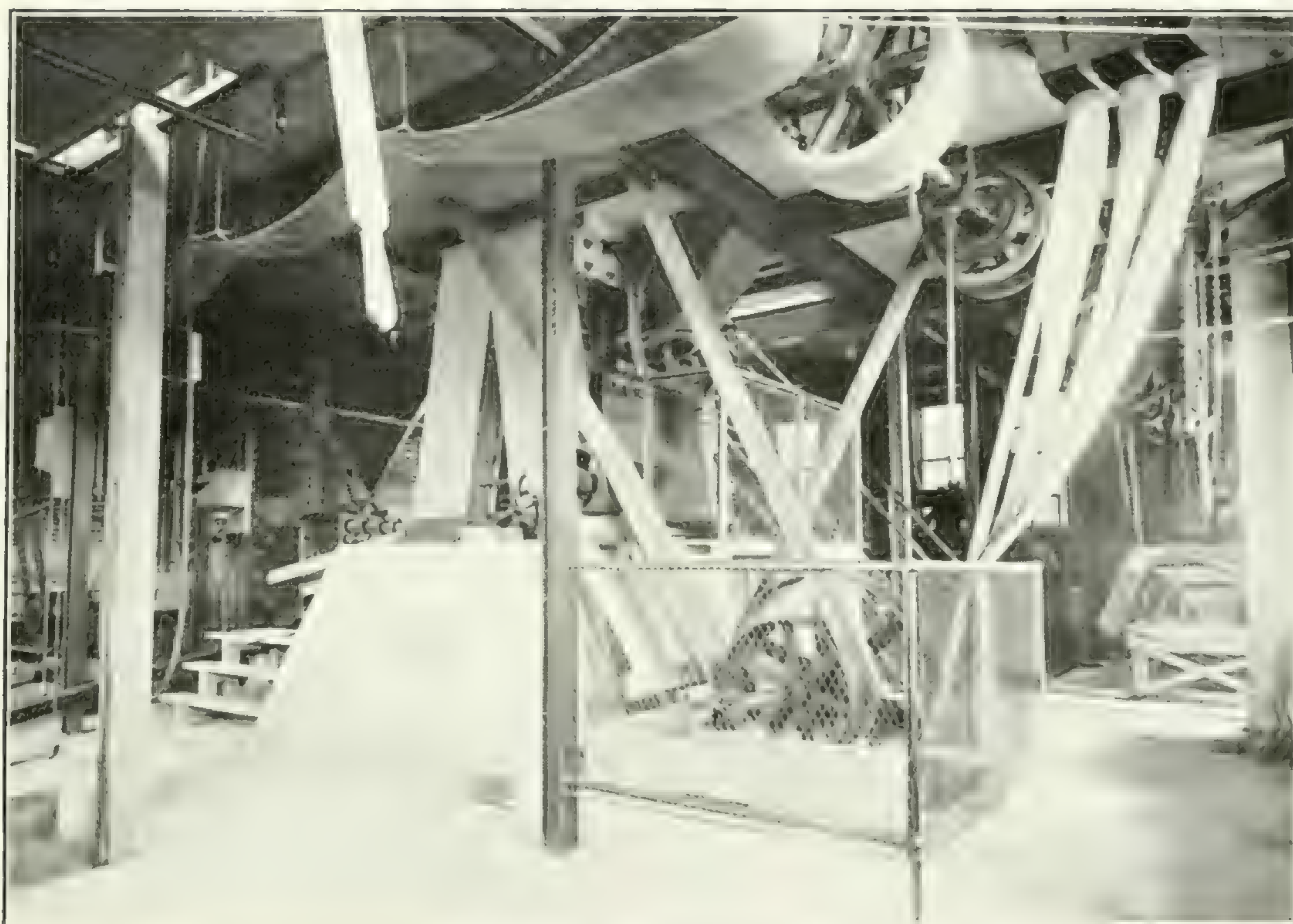


Ore dressing laboratory: Richards pulsator, jig, and classifier



Ore dressing laboratory: crushing rolls.

PLATE XLIII.



Ore dressing laboratory: rear of stamp battery.



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floor. The separation depends on the strength of the magnets, regulated by the rheostat on the switch-board; the rate of travel of the belt, regulated by moving a belt on the cone pulleys; the feed adjusted by the feeder gate and speed cones, and the amount of hydraulic water used regulated by valves on the water lines.

Cyanide Plant.

The cyanide plant consists of :—

- Two storage solution tanks,
- One Parral tank for agitation,
- One air pump and receiver,
- One slime press,
- One clarifying box,
- One gold solution tank,
- Six precipitation boxes,
- One sump tank.
- One rotary pump,
- One filter press for precipitates.

In addition to the above, there will be installed: one set of cyanide jars, fitted with agitators, for making small preliminary tests.

The *two storage solution tanks* are placed on a platform at the top of the building. The tanks are of steel, 3 feet diameter by 3 feet high, and are connected together so that they can be used for one strength of solution, or separately where two strengths of solution are required. From the bottom of the tanks a pipe line runs to the Parral agitator.

The *Parral agitator* is a steel tank, 3 feet diameter \times 4 feet high, set on an intermediate floor below the solution tanks. It has a $2\frac{1}{2}$ " discharge, opening at the centre of the bottom, and a $1\frac{1}{2}$ " opening one foot from the top of the tank through which the solution after agitation is decanted from the tank through a pipe line into the clarifying box. Inside the tank are four $2\frac{1}{2}$ " stand pipes, spaced equidistant from one another, and 12" from the centre of the tank. The bottom of the stand pipes are 3" from the bottom of the tank, held in place by supports to the bottom. The upper end is held in place by supports to the side of the tank. On the top of the stand pipes are $2\frac{1}{2}$ " tees, the centres of which are 6" from the top of the tank. The tees point in the same direction, tangential from the circumference of a 12" radius circle. On the top of the tees is a cap, through which a $\frac{1}{4}$ " pipe runs down the centre of the stand pipe. On the bottom of the $\frac{1}{4}$ " pipe is a tee, the centre of which is 3" from the bottom of the stand pipe and 6" from the bottom of the tank. The $\frac{1}{4}$ " pipes are connected at the top with the air line from the receiver of the air pump.

The charge to be agitated is dumped into the tank. Solution is added from the storage tanks. The charge is violently agitated by the air through the stand pipes and given a swirling motion by the force of the discharge. After agitation, it is allowed to settle, the clear solution is decanted off and fresh solution added for a second agitation. This operation is repeated until the decanted solution shows a low percentage of values extracted. The charge is then drawn off through the $2\frac{1}{2}$ " discharge opening, and pumped into the slime press.

An *air pump* is used for supplying air for agitation. This has a single plunger, 6" in diameter with an 8" stroke, 19.5 cu. ft. of free air displacement at 150 R.P.M. The cylinder is provided with radiating air cooling rings, and a continuous pressure of 30 pounds can be maintained without danger of overheating. A $2\frac{1}{2}$ " pipe intake runs from the outside of the building to the $1\frac{1}{4}$ "

intake of the pump. A $1\frac{1}{4}$ " discharge connects the pump with the receiver. The receiver is 15" in diameter and 6 feet long, equipped with pressure gauge and unloading valve.

The *Perrin filter press* has 12" diameter frames. It is connected with the Parral agitator and used as a slime press, for recovering the solution from the slimes. After the values have been extracted by agitation in the Parral tank, and the clear solution decanted off, the slimes are pumped through the press, caked, washed and discharged. The solution from the press is carried by a pipe line to the clarifying box.

The *clarifying box* is 12" square inside, by 18" high, equipped with a filter bottom of wood slats, diverging towards the centre, on top of which two layers of cocoanut matting are laid, and the box filled with excelsior. The solution is clarified in the box before entering the gold tank, from which it flows to the precipitation boxes.

The *gold tank* is of tank steel, 3 feet in diameter \times 3 feet high. The solution enters through a pipe line from the clarifying box. If necessary, the tank can be equipped with a filter bottom, and used for leaching purposes.

The *precipitation boxes* are 1 ft. square, and are set on a stand, one slightly raised above the other, so that they can all be used if necessary. On the solution line to the boxes is placed a $\frac{1}{8}$ " drip cock for collecting a head sample of the solution before entering the boxes, and on the line from the boxes to the sump tank another drip cock for collecting a tail sample from the boxes.

The *sump tank* is of tank steel, 3 feet diameter \times 3 feet high, set on a frame on the ground floor, beneath the precipitation boxes. From the bottom of the tank a $1\frac{1}{2}$ " pipe line connects it with the suction of the rotary pump. The solution can be brought up to strength by the addition of cyanide in the sump tank, gold tank, or the two storage tanks at the top of the building.

The *rotary force pump* has a capacity of about 15 gallons per minute, a $1\frac{1}{4}$ " suction and $\frac{3}{4}$ " discharge. It is used for pumping the solution from the sump tank to the storage tanks at the top of the building.

A small *Perrin filter press*, 6" diameter filter frames, is used for pressing the solution from the precipitates. The solution from the press is emptied into the sump tank, the precipitates being caked in the press.

LARGE SCALE MACHINERY AND APPARATUS.

Crushing and Grinding.

The crushing and grinding machinery consists of:—

- One Hadfield and Jacks 12" \times 8", Blake crusher,
- One Allis-Chalmers 24" \times 14", style "C" crushing rolls,
- One Hardinge 4'-6", conical mill,
- One Allis-Chalmers 5-stamp battery.

The *Blake crusher* is placed on one side of a platform, at the rear entrance to the building. The ore is dumped on the platform, in which is set a heavy flat casting, on which lumps too large for the crusher are broken. From the platform the ore is shovelled into the crusher. The pulley on the line shaft from which the crusher is driven is provided with a friction clutch, so that the crusher can be thrown off or on without interfering with the operation of the other machinery.

The *crushing rolls* are placed on the second floor and are fed automatically by a push feeder below the storage bin. A push feeder delivers the ore to a chute, lined with iron, in which are placed triangular cast iron blocks for distributing the ore evenly across the width of the rolls. The rolls are thrown in and out of operation by a friction clutch on the driving pulley on the main line shaft.

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The *Hardinge conical mill* is placed on a concrete foundation on the lower floor. It is used for fine crushing. Dry or wet crushing may be accomplished in the mill. The ore is delivered to the mill from a Vezin sampler above the second floor through a chute lined with flat iron. The mill is thrown in and out of operation by a pulley equipment with a friction clutch on the main line shaft.

The *five-stamp battery* is set on a concrete block in the centre of the plant. The battery is supported by an "A" frame, set in cast iron shoes bolted to the block. The weight of each stamp is 1,250 pounds. A Challenge suspended feeder feeds the ore automatically into the mortar. The feeder is supplied with ore from the Vezin sampler above the second floor through a chute lined with flat iron. The battery is thrown in and out of operation by a pulley equipped with a friction clutch on the main line shaft.

Conveying.

The ore is conveyed to and from the various machines by elevators, spiral conveyers, chutes, pumps, launders and pipe lines.

From the jaw crusher it is lifted by a bucket elevator to the top of the building, discharged into spiral conveyers, which convey it to two ore bins. From one of the bins it is fed, by a push feeder, through a chute to the rolls, or through another chute to the Keedy sizer. From the other bin it is fed by a push feeder to a bucket elevator, which discharges into a Vezin sampler. From the sampler the ore runs by gravity in chutes lined with flat iron to the stamp battery, to the Gröndal dry separator, to the Hardinge mill, or on to the feed platform at the back entrance of the building. The chutes are so arranged that they can be removed when the machinery is not in operation.

Three 2" centrifugal pumps are placed on the ground floor to force the pulp from the stamp battery, the tailings from the Deister and Overstrom tables, and the tailings from the Gröndal wet separator to the cone classifiers and settling tanks. A 1" centrifugal pump lifts the concentrates from the Gröndal wet separator into a cone settling tank.

Launders are used to convey the overflow slimes from the cone classifier to the settling tank, the coarse and fine sands from the Callow screens to the launder and cone classifiers, and the overflow water from the cones to the sump tanks below the floor level.

Pipe lines are used in a number of cases for conveying the finely crushed material to and from the various machines.

Sampling.

Sampling of the coarser material is accomplished by passing the ore through Vezin samplers. One sampler is placed beneath the rolls, the discharge from the rolls passing through the sampler to a Ferraris screen. The feed to the Gröndal dry separator, stamp battery and Hardinge mill passes through the other Vezin sampler. The samplers are adjusted at present so that the sample is one-tenth of the feed to the machines.

For cutting down the sample, two sets of Jones rifled samplers are used.

Sampling of the fine material is accomplished by a system of eight Flood automatic samplers, placed throughout the mill, and operated by a master clock on the switchboard. A sample is cut out of any feed, or discharge, every fifteen minutes.

Drying.

Ore that requires drying before treatment is dried in a gas drier, placed on the lower floor on one side of the platform at the rear entrance. The drier is also

used for determining moisture in the ores, and for drying the samples. A sand drier is also used where it is necessary to dry large amounts of sand, etc.

Sizing and Screening.

The sizing and screening machinery consists of:—

- One Ferraris screen,
- One Keedy sizer, No. 3,
- One duplex Callow screen.

The Ferraris screen is placed on the ground floor. The ore is fed to the screen from a Vezin sampler, through a chute lined with flat iron, in which are placed triangular pieces of cast iron for distributing the feed over the screen. The screen is given a vibratory motion endwise by means of an eccentric which is adjusted to give it the required throw. The speed is regulated by stepcones. The screen is used for coarse sizing. The screens used are 1" round, $\frac{3}{4}$ " round, $\frac{1}{2}$ " round, $\frac{1}{4}$ " straight slot, $\frac{1}{8}$ " straight slot, and $\frac{1}{16}$ " diagonal slot. The machine is thrown in and out of operation by a friction clutch on the line shaft pulley.

The Keedy sizer is used for fine sizing, and consists of a network of screens enclosed in a box. The ore is fed into the sizer at the top, passes over the screens, the various sized products drawn off by gravity, and the motion of the sizer, into compartments below the machine. The feed is screened into sizes ranging from from ten to two hundred mesh. The sizer is thrown in and out of operation by shifting the driving belt onto the fast or loose pulley.

The duplex Callow travelling belt screen is placed on an intermediate floor above the second floor. The feed to this machine is from a cone classifier above the screen. The desired classification is made by the mesh number of the belt screen used. The machine is constructed so that one side can be used at a time or both sides together, if necessary. The travel of the belt screen is regulated by step cones to suit the screening desired. Two products are made, a fine and a coarse sand product. The coarse sand product flows into a cone settler beneath the screen, and the fine sand product to a launder classifier for hydraulic classification.

Classification, Settling and Dewatering.

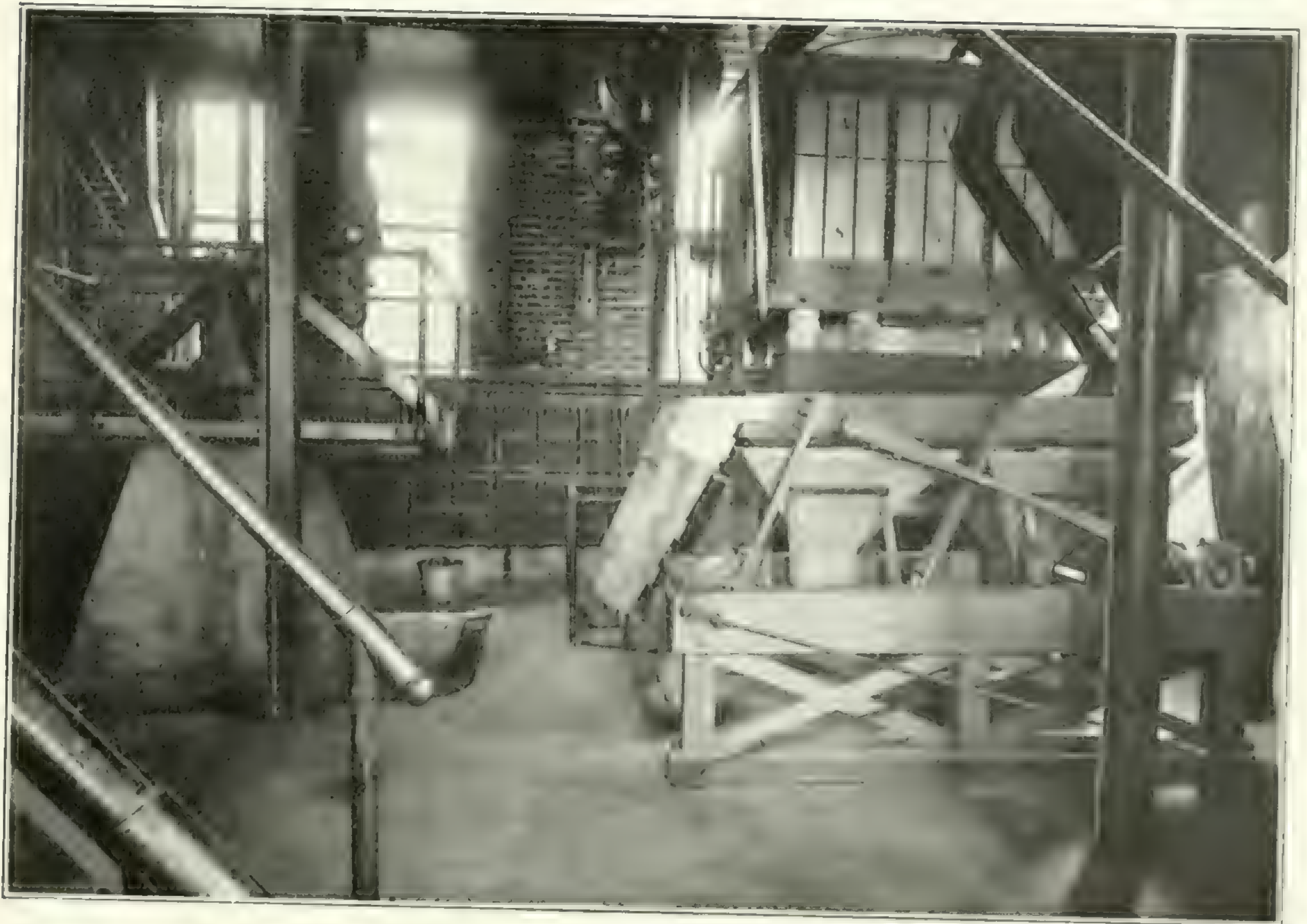
Classification, settling and dewatering are carried out in:—

- Six—8' callow tanks.
- Two Richards launder classifiers.
- Three sump tanks.

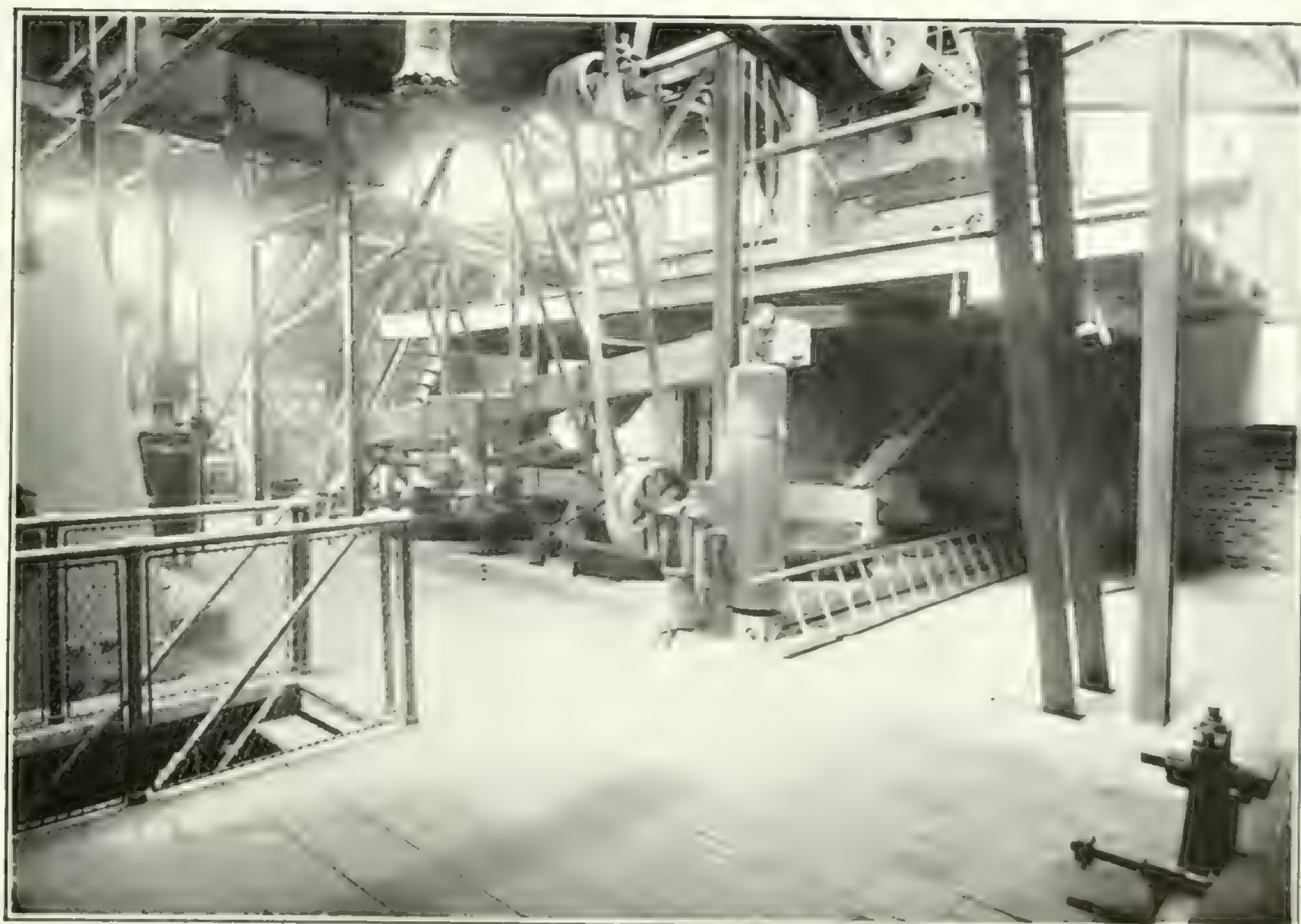
The Callow tanks are of tank steel, 8' diameter \times 8' high, set in wood frames. One cone is placed near the top of the building and supplies a deslined feed to the Callow screen. Five cones are placed on the second floor and receive the products from the pumps, the slime overflow from the upper Callow tank, and the coarse sand from the Callow screen. They are used for settling and dewatering purposes, the overflow being carried into the two cement sump tanks before the ground floor level.

The Launder classifier consists of a launder 10" wide by 10" deep. It has two settling pockets, to which are attached sorting columns and pulsator valves. The first classifier has a $2\frac{1}{2}$ " sorting column, pulsator valve and air chamber, with a No. 1 cast iron settling pocket. The second classifier has a 4" sorting column, pulsator valve, and air chamber, with a No. 3 cast iron settling pocket. The material to be classified is fed to the launder from the Callow screen, the coarser material is drawn from the spigot of the first classifier and is sent to an Overstrom table. A fine sand product is drawn from the spigot of the second classifier to the Deister table. The finer sands flow into a cone settling tank, below the discharge of the launder.

PLATE XLIV.



Ore dressing laboratory: Ferraris screen for coarse sizing in foreground; Keedy screen for fine sizing in background



Ore dressing laboratory: Richards launder, pulsator, classifiers, Callow screens, and tanks.

PLATE XLVI.



Ore dressing laboratory: view on first floor, Callow tanks, stamp battery, cyanide zinc boxes.



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Amalgamation.

In amalgamating gold and silver ores, the experiments may be carried out :—

Firstly: In the battery mortar.

Secondly: On the amalgamating table.

Thirdly: In a Pierce amalgamator.

If desired, the mortar of the five-stamp battery can be arranged for inside amalgamation. The battery is equipped with a ten-foot tilting table, which can be raised or lowered by means of two jacks under the frame, to give it any desired slope. The crushed ore passing through the mortar screen falls in succession on the lip plate, the upper table plate, the second table plate and the lower table plate, into the Pierce amalgamator. From the Pierce amalgamator it is carried to a two-inch centrifugal pump, which forces it to the upper cone classifier.

Concentration.

The concentrating machinery consists of:—

One two compartment Richards jig,

One sand Overstrom table,

One Deister slime and fine sand concentrator.

The Richards, 6", two compartment, pulsator jig is placed on a concrete block on the ground floor, at sufficient elevation so that the products from the jig can be drawn off into tanks or tubs placed on the floor. The jig will treat sized products up to 1". The feed is delivered to the jig by a launder from a push feeder on the second floor. Hydraulic water at constant head is supplied from a tank on the second floor. The pulsations are regulated by step cones on the driving counter to suit the material to be jigged. The operation is similar to that of the laboratory jig described above. Three products are obtained: a concentrate from the first compartment, a middling from the second compartment, which can be crushed and retreated, and a tailing passing over the discharge spout.

The Overstrom table is placed on the lower floor. The feed is supplied to the table either from the launder classifier, or from a push feeder on the second floor. The table is adjusted to suit the feed and the concentration required, by raising or lowering the table, by giving it a longer or shorter throw, and by regulating the speed by step cones. Two products are made, a concentrate and a tailing. The tailing box is connected with a 2" centrifugal pump, which elevates the tailing into one of the cone classifiers.

The Deister concentrator is placed on the ground floor, near the Overstrom table, and is fed from the launder classifier or from a push feeder on the second floor. The adjustments are similar to those of the Overstrom table. Three products are made, a concentrate, middling and tailing. The tailing box is connected with a 2" centrifugal pump, which elevates the tailing into one of the cone classifiers.

Magnetic Separation.

The magnetic separating machinery consists of:—

One Ullrich wet and dry separator,

One Gröndal dry separator.

One Gröndal wet separator.

The Ullrich four-pole, wet and dry separator is placed on a concrete block on the lower floor. The separator receives its feed from a push feeder on the

second floor. The feed is equally distributed to four shaking feeders, which carry the ore under four circular secondary polar rings. The magnetic particles are picked up by the rings, carried out of the field and dropped into separate compartments; the non-magnetic particles are carried on by the feeders and discharged at the centre of the machine. The separator is designed for the separation of either strongly magnetic or weakly magnetic minerals from one another, or from their gangues. The separation depends on the following adjustments:

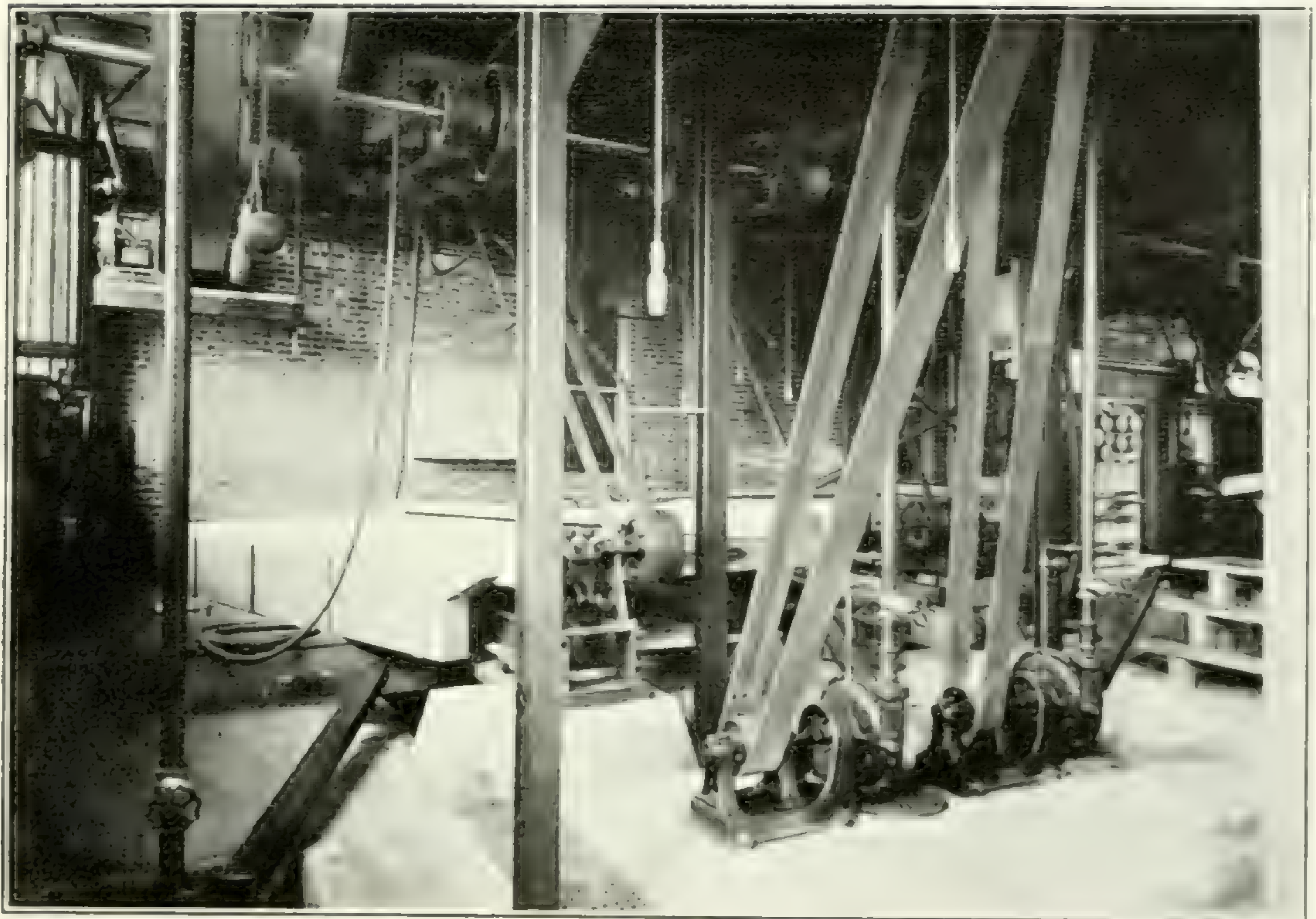
- (1) Strength of the current, regulated by a rheostat on the switchboard.
- (2) The distance of the polar rings from the feed. The rings may be adjusted by raising or lowering them so that strongly magnetic minerals are drawn out by the outer rings, and the weakly magnetic minerals by the inner rings.
- (3) The rate of feed. The feed should be regulated so that only one layer deep of particles lie on the feeders, thus preventing entanglement of the particles in the magnetic field.
- (4) The amount of feed water used.

The Gröndal dry separator is placed on the second floor. It receives its feed through a chute from a Vezin sampler. The feed is evenly distributed on an endless belt, travelling around two drums. The feed first comes under the influence of rectifying magnets under the belt. Travelling onward with the belt, it passes through the field of the drum magnets, the non-magnetic particles are thrown forward from the belt as it passes around the drum, the weakly magnetic particles drop into a middling compartment; while strongly magnetic particles cling to the belt, and are carried until they pass out of the field and are dropped into a third compartment. Any dust in the ore is drawn to a dust collector by a suction fan. The separation depends on the following adjustments:—

- (1) The current strength, regulated by rheostats on the switchboard. The rectifying or belt magnets have a separate rheostat, ammeter and switch from the drum magnets, so that any strength of current desired can be carried on either set of magnets.
- (2) The rate of travel of the belt regulated by step cones on the driving counter.
- (3) The rate of feed. Particles must be evenly distributed on the belt, and only one particle in depth.
- (4) The position of the drum magnets, adjusted by a lever from the centre of the drum.
- (5) The adjustment of hinged and sliding vanes separating the discharge compartments.

The Gröndal double drum wet separator is placed on the lower floor. It receives its feed through a launder from the tube mill discharge. The feed, held in suspension in the feed compartment by a head of hydraulic water, passes over a weir and comes under the influence of the magnets inside the brass drum; the magnetic particles cling to the drum, the non-magnetic particles flow over the weir into the tailing compartment. The magnetic particles are washed off the drum by a spray of water into a concentrate compartment, and flow out into the feed box of a second machine, to be re-concentrated in a similar manner. The separation depends on the following adjustments:

- (1) The strength of the current, regulated by rheostats on the switchboard. Each set of drum magnets has a separate rheostat, ammeter and switch, so that the field of each drum can be varied at will.
- (2) The distance of the feed from the drums, regulated by raising or lowering the compartment boxes below the drums.
- (3) The amount of hydraulic water used.



Ore dressing laboratory: Overstrom and Deister tables, sand pumps in foreground.

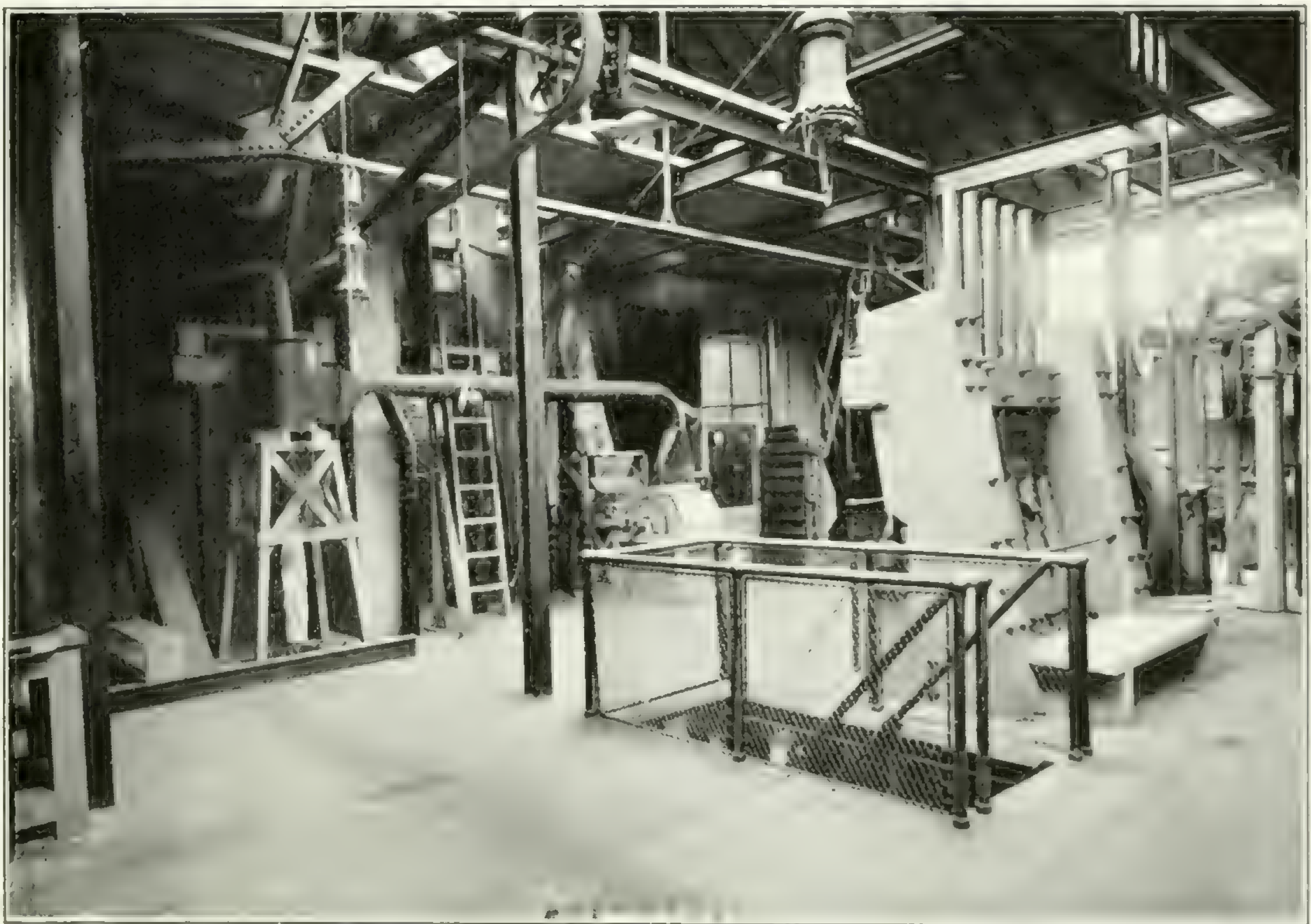


PLATE XLVIII.



Ore dressing laboratory: Ullrich magnetic separator, left;
Richards pulsator jig, right.

PLATE XLIX.



Ore dressing laboratory : view on second floor, Huff machines, stamp battery, Gröndal cobber.



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Electrostatic Separation.

The electrostatic apparatus consists of:—

- One Huff single roll separator,
- One Huff toboggan separator for fine material,
- One Huff generator set.

The electrostatic separator is utilized to effect separations of the minerals in ores, with respect to their relative electrical conductivity: every mineral, if subjected to a sufficiently high voltage, conducts electricity to some extent. As minerals differ in their readiness to conduct, it follows that when a mixture of minerals is subjected to a charging influence, there will be a difference in the time required for the various minerals to become electrically charged; and, conversely, if all the minerals of a mixture become charged in some manner, there will be a difference in the time required to discharge, when in contact with a discharging surface.

Minerals may be divided into two general classes of good and poor conductors. Minerals of one class can usually be separated electrostatically from minerals of the other class. Some minerals, however, belonging to one class in their pure state may come under the other class by the impurities which they may contain. The conductivity of the minerals may be altered by heat, chemical or electro-chemical action, thus making them susceptible to electrostatic separation.

Electrostatic separation is employed for:—

- The concentration of copper sulphide minerals,
- The separation of zinc minerals,
- The concentration of sulphide ores,
- The concentration of graphite, molybdenite, hematite, copper oxides, carbonates and silicates, and other rare minerals from their associated gangue.

The Huff apparatus is placed on the second floor. The single roll separator is used on the coarser sizes. The number of passes necessary to make the separation on this machine is carried out in practice by one machine with the required number of rolls. The separator for the finer sizes is a six stage toboggan machine. The stages are built up of cast iron pieces, highly polished on the sides in contact with the ore, so that the ore glides easily from one stage to the next over the polished surface.

Static electricity is generated by a generator set, enclosed to keep it free from dust. The current is generated at a low amperage and high voltage, and is stepped up by a transformer in ratios of one to one hundred. The voltage used at the electrodes of the machine varies from 10,000 to 35,000, and is regulated by two field rheostats on a panel switchboard.

Concentration by Oil Flotation.

Provision has been made for the installation of an oil flotation unit, which will be undertaken during the coming summer.

Roasting and Sintering.

A roasting and sintering plant will be installed in the roaster building, to be erected in the spring.

Power and Transmission.

The power and transmission machinery consists of:—

One 40 H.P., D.C. motor,

Two 25 H.P., A.C. motors,

One 5 H.P., A.C. motor,

One 5.5 K.W. generator set,

One .5 K.W. generator set,

Two main line shafts for large scale machinery,

One main line shaft for laboratory machinery,

Intermediate shafts, pulleys, step-cones, belt and cone shifters, leather and balata belting, friction clutches, belt tighteners, etc.

The 40 H.P., D.C. motor receives its power from a 50 K.W. direct current generator, direct connected to the gas engine of the Fuel Testing Division. It is placed on the ground floor, in one corner of the building, and drives the main line shaft of the laboratory. It is used as an auxiliary to the 25 H.P., A.C. motor.

The 25 H.P., A.C. motor receives its power from two 25 K.W., A.C. transformers. It is placed on a platform under the second floor, in a corner of the building, supported by the walls.

The 5 H.P., A.C. motor is placed above the second floor, and drives the line shaft of the laboratory machinery independent of the large scale machinery.

The 5.5 K.W. generator set is placed in the corner of the building above the 40 H.P., D.C. motor. It supplies direct current for the fields of the magnetic separators.

The Huff electrostatic generator set consists of:—

One $\frac{1}{2}$ K.W., 4 ampere, 110 volt, D.C. generator,

One 3 H.P., single phase, 33 ampere, 110 volt, induction motor, direct connected with:—

One 1.5 KV-A-5 ampere, 300 volt, A.C. generator,

One Wood system transformer, capacity 5 KV-A, volts 350—35,000.

The voltage is controlled by two field rheostats on the panel.

Two main line shafts drive the large scale machinery. Most of the machinery on the ground floor is driven direct from the line shafts, thrown in and out of operation by friction clutches on the pulleys. Intermediate shafts from the line shafts drive the balance of the machinery on the ground and second floors. The proper speed is given the shafts and machines by various sized pulleys. Step cones are used in a number of cases where several speeds are required. The machines are thrown in and out of operation by friction clutches on the pulleys, and by belt shifters, which move the belt onto the fast or loose pulley. Tighteners are used with the cone pulleys and larger belts to take up the slack.

Switch Boards.

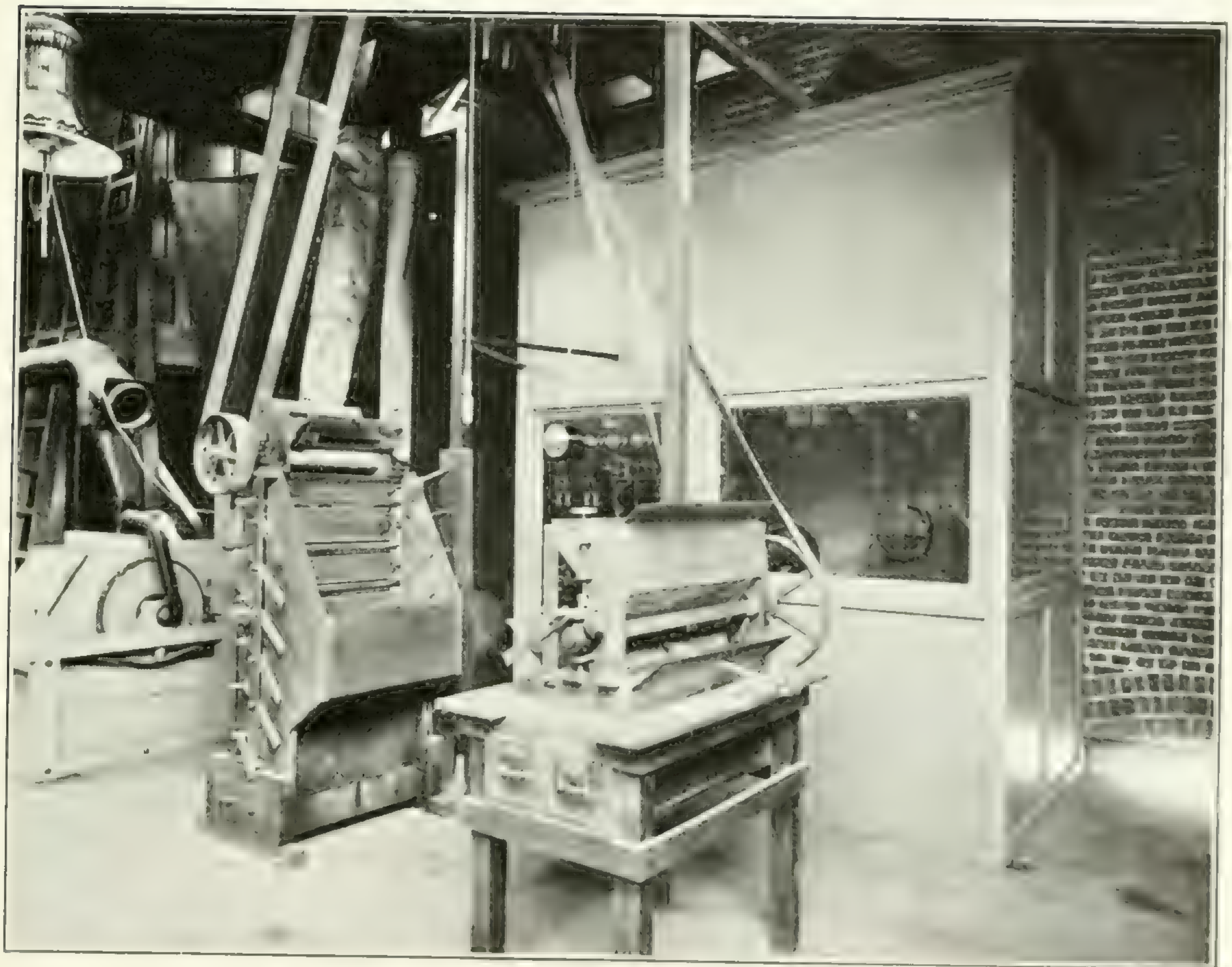
Besides the main switchboard in the engine room, a sub-board of two panels is placed in the laboratory. On these panels are placed the switches for the motors, generator set, and the switches for the fields of the magnetic separators. The voltmeters and ammeters are placed above their corresponding switches.

A rheostat board for the magnetic separators is placed to one side of the sub-board, from which the current strength of the magnets is regulated.

A small board is placed on the second floor, on which are the rheostats, meters and switches for the laboratory wet and dry separators.

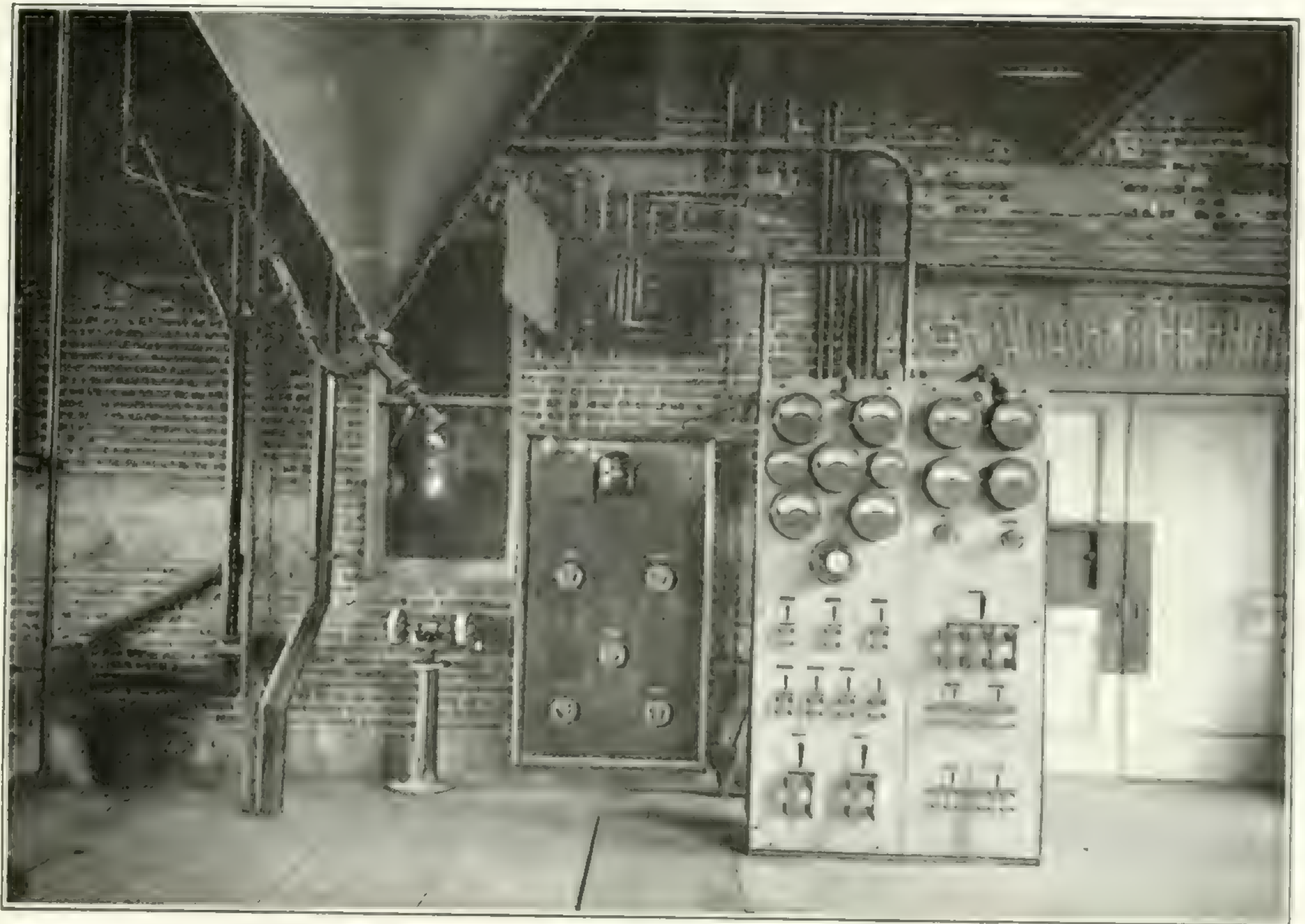
On the Huff electrostatic panel are placed the two rheostats for raising or lowering the voltage on the electrodes, the voltmeter, switches and starting compensator.

PLATE L.

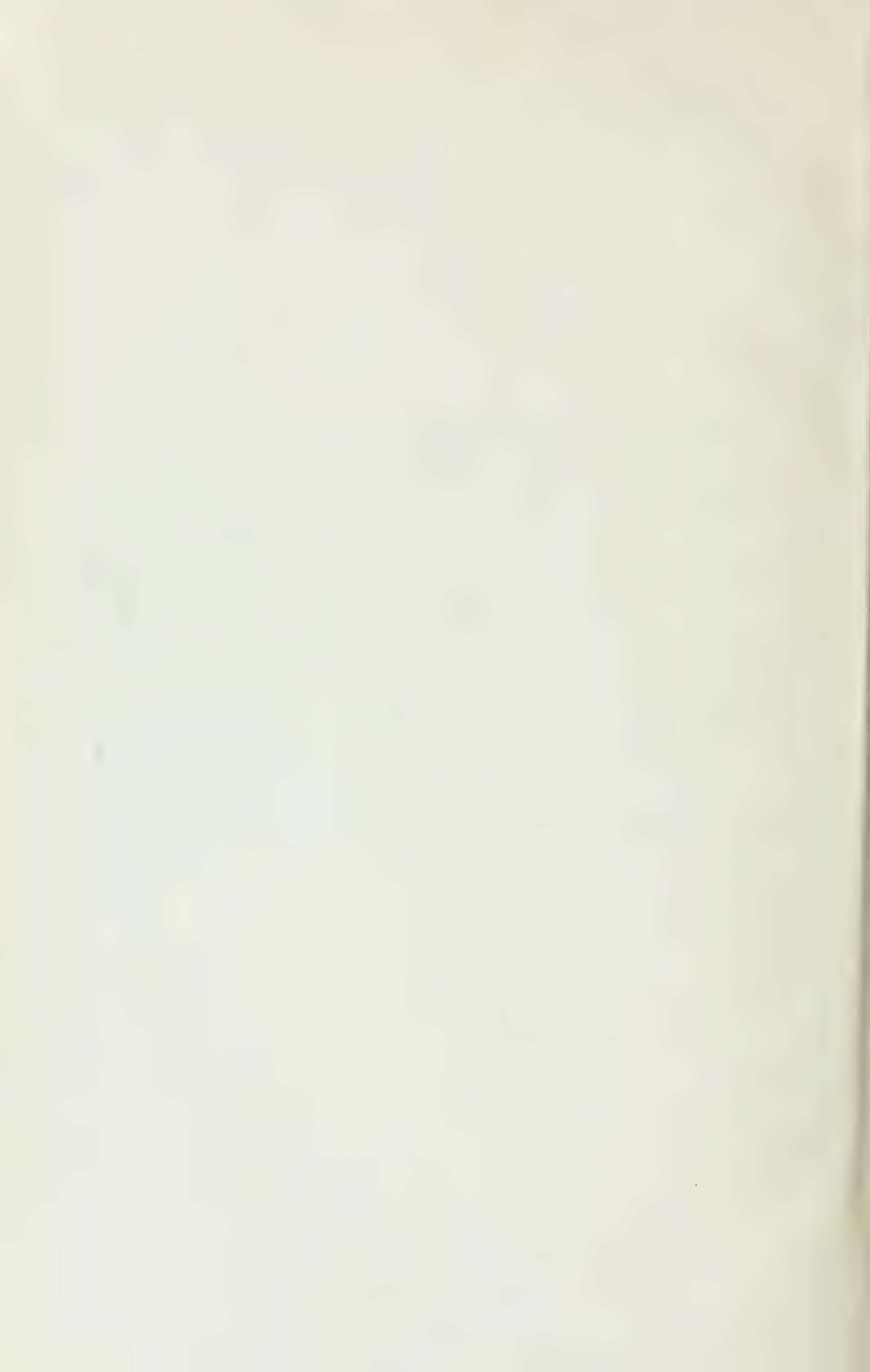


Ore dressing laboratory: Huff electrostatic laboratory separators, generating apparatus in case in background.

PLATE LI.



Ore dressing laboratory: switch board and rheostat board.



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Water Supply.

The machines are supplied with water through pipe lines and launders. Water meters are placed on the lines to measure the amount each machine is using while in operation. In the case of the jigs, where a definite head of hydraulic water is required, the water is supplied from tanks set at the proper elevation.

CHEMICAL AND ASSAY LABORATORIES.

The chemical and assay laboratories are equipped for making all analyses and assays required by the ore testing plant. They are part of the new building and comprise six rooms between the Fuel Testing and Ore Testing Plants.

MACHINE SHOP.

The machine shop is equipped with the following machines:—

One Pratt and Whitney 16"×10 ft. lathe,
One Brown and Sharpe milling machine,
One Brown and Sharpe grinding machine,
One Henry and Wright drilling machine,
One McDougal drilling machine,

To the present equipment will be added a grinding machine and a shaper for dressing and shaping the rougher castings.

The shop was used in equipping the plant, and will be used for general repair work, and the making of new apparatus for the Fuel and Ore Testing Laboratories.

STOREHOUSE.

A stock of supplies is kept in a room at one side of the machine shop. Records are kept of all material and supplies received and issued to the Fuel Testing Station and Ore Dressing Laboratories.

EXTENSIONS AND NEW EQUIPMENT.

An extension to the fuel shed, for the purposes of an ore shed, will be built. Shipments of ore and test products from the plant will be stored in this shed.

A roaster building, 30 feet wide×58 feet long, will be built, to contain an experimental roasting and sintering plant.

Provision has been made, and space left in the laboratory for the installation of a flotation process for the concentration of ores.

To the present cyanide plant equipment will be added a set of cyanide jars, with agitating propellers for making laboratory cyanide tests.

DIFFERENT KINDS OF TESTS.

Two kinds of tests are conducted: (1) Preliminary, and small scale tests, (2) Mill, or large scale tests.

Preliminary and small scale tests are made on shipments up to 600 pounds, by the use of the laboratory apparatus. Every likely combination is tried, and all data and facts recorded and tabulated.

Mill or large scale tests are made on shipments over 5 tons. The best mode of procedure, and the proper flow sheet having been determined by small scale tests, the large machinery is adjusted to conform with the requirements, and the shipment run under actual mill conditions.

QUANTITY OF ORE REQUIRED.

For preliminary and small scale tests, not less than 200 pounds will be received.

For mill or large scale tests, shipments should not be less than 5 tons.

SHIPMENTS.

All shipments must come bagged, and be consigned, prepaid, to the Mines Branch, Department of Mines, Ore Testing Laboratory, corner of Plymouth avenue and Division street, Ottawa.

ASSAYING.

Assays, and analyses of the necessary samples are made by the Mines Branch officials, in the laboratories at the plant.

CHARGES.

Tests of Canadian ores—including assays and analyses necessary for test purposes—are conducted free of all charges; but all testing products become the property of the Mines Branch, unless otherwise arranged before commencement of tests.

TESTS CONDUCTED.

Tests are conducted by the officials of the Mines Branch; but arrangements may be made, whereby engineers and other competent persons may supervise their own experiments, except where tests are made on machines and by processes on which it has been necessary to guarantee the protection of patents.

REPORTS.

Reports of tests will be incorporated in the publications of the Mines Branch, but separate copies of particular tests will be given to owners of samples when their tests are completed.

APPLICATIONS.

Applications for the testing of ores, and all communications regarding the arrangement of tests should be addressed to the Director, Mines Branch, Department of Mines, Ottawa.

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